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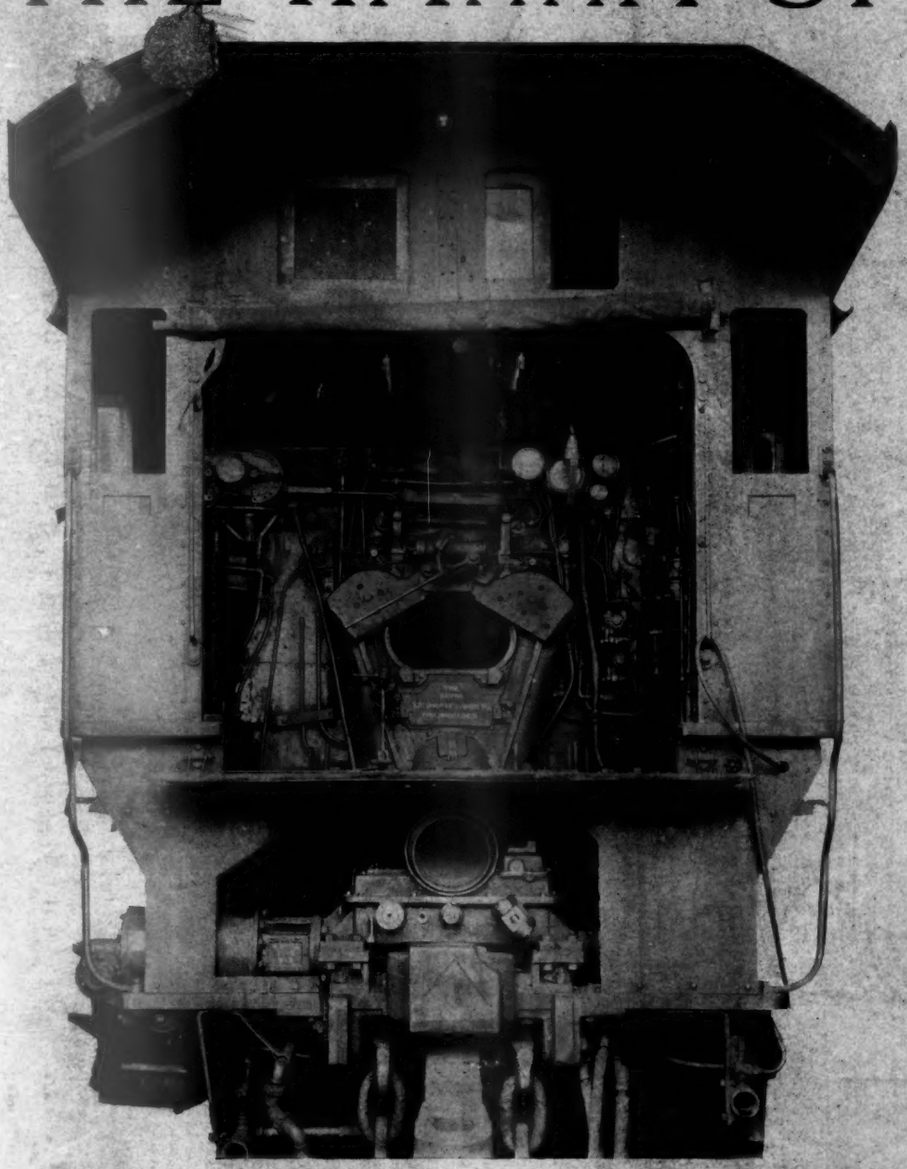

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Railway Mechanical Engineer

Volume 95 August, 1921 No. 8

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A Good Piece of Committee Work

In its final report, an abstract of which appears elsewhere in this issue, the Committee on Air Consumption of Locomotive Auxiliary Devices of the Air Brake Association has completed an exceptionally good piece of work. The investigation was undertaken largely because the constantly increasing draft on the locomotive air compressor to supply these devices threatened the integrity of the air brake system, and it had for its main purpose the development of measures for the protection of the air supply for the operation of the brakes. In the course of its investigation the committee found the immediate difficulty to lie in the excessive air consumption of these devices, single units frequently exceeding the capacity of the pumps while in operation, and found the remedy to lie in the establishment of and adherence to a higher standard of maintenance. Too frequently, similar committees consider their work completed at this point, relying on general recommendations to effect the desired improvement in conditions. But this committee went further. Not only did it recommend a definite minimum standard of performance as a condemning limit and develop a simple and practicable method for its application, but it made a study of the economics of the maintenance of these devices, the result of which can leave little doubt in the mind of any mechanical department officer as to the dollars and cents value of the net return to be obtained from the additional expenditure required to keep them up to the recommended standards. The value of the report lies not so much in the manner in which the technical problems involved in the subject have been handled as in the sound business principles by which the committee has been guided in its investigations and in the formulation of its reports. The committee has wisely placed less stress on the primary object of its work than on the more tangible, though no more important, value of a higher standard of maintenance in saving the cost of producing unnecessary compressed air, and it has thereby developed a selling argument by the use of which the probability of attaining its main object has been very greatly increased.

Chemical Limits Specified for Iron Car Wheels

The importance of the standard specifications adopted by the American Society for Testing Materials is evidenced by the fact that they are widely recognized, universally respected and extensively followed. The reason for this lies in the fact that users, manufacturers and disinterested engineers and metallurgists are not only members of the society and serve on its committees, but also attend the annual meetings in force and take an active part in the discussions and determinations of these specifications. This was very clearly shown by the results of the 1921 meeting.

The most important action taken at this convention was the adoption of a tentative specification for chilled cast-iron car wheels and the inclusion in these specifications of chemical requirements as well as physical tests. The original draft of the specifications, as submitted by the committee, did not include chemical limitations, but as a result of a long discussion and in response to insistent demands on the part of car wheel manufacturers as well as railroad representatives, an analysis was agreed upon which will have a far-reaching effect on the whole car wheel industry. The improved service which undoubtedly will follow from the adherence of manufacturers to the chemical requirements laid down in this specification will be of the greatest value to the railroads of this country, who have been loath to abandon chilled cast-iron

wheels despite the steadily increasing severity of the requirements imposed by changing operating conditions and increasing wheel loads.

Locomotive Cut-Off Control

The article on the "Automatic Control of Locomotive Cut-Off" published elsewhere in this issue, opens a wide field for discussion regarding economical locomotive operation. Probably no one will deny there are opportunities for improvement through scientific control of cutoff, but it is questionable whether the most desirable results would be obtained by making the cutoff dependent on the back pressure, at least in the present state of development of this method. The regulation of cutoff to produce a fixed back pressure is based on the theory that under certain conditions, shortening the cutoff produces an increase in the drawbar pull. However, experimental data shows that this is true only over a limited range and holds good only with comparatively long cutoff. Furthermore, the decrease in drawbar pull at longer cutoffs is primarily, if not entirely, due to a decrease in the steam pressure in the boiler, and it is an open question whether the decrease in the pressure does not furnish the best indication as to the advisability of shortening the cutoff.

The Throttle vs. the Reverse Gear

It is an interesting coincidence that at the time when automatic means of controlling cutoff are being considered in this country, a British technical periodical should discuss the time-worn subject of notching up vs. throttling. Representatives of the London publication, The Engineer, have recently completed a series of observations of locomotive handling on a number of important British railways. Our British contemporary compliments the skill of the enginemen and goes on to say: "When one observes the amount of driving that is done with the throttle instead of the reverse gear, and when one considers the little real knowledge of the superheater, it is difficult not to feel that effort is necessary to educate drivers in the handling of their engines better than hitherto." It was found that some drivers notched the engines up to some point varying from 30 to 50 per cent cutoff and regulated the power output by throttling. One engineman gave as the reason for not using an early cutoff the fact that the short valve stroke wore the valve spindle unequally. The Engineer points out that part of the advantage of superheating may be lost by such operation and states in conclusion: "It will be seen that we are under the impression that there is room for improvement in the manner that locomotives are often operated. Any improvement made by the better use of the expansive properties of steam will bring its certain return in decreased operating costs. This result can be obtained without incurring any expenditure. It is an economy secured by making better use of the locomotive as it is, without the addition of further devices. Modernizing steam locomotives calls for intelligent use being made of the devices fitted. Let us see that enginemen are helped to handle their locomotives efficiently. They must be taught the value of a wide open throttle, and of the expansive properties of high-pressure steam, and to assist them in the proper handling of the superheater must be given a pyrometer, which is as necessary to the working of the superheater as is the pressure gage to the boiler. We have heard it said that given a good pyrometer a steam gage is unnecessary. That may or may not be so. Certain it is, however, that given proper temperature readings, the steam pressure is practically sure to be right, but, on the other hand, satisfactory boiler pressure shown on the steam gage is by no means a guarantee that the temperature of the steam delivered to the engines is satisfactory."

Does Abrasive Adhere to Ground Surfaces?

The statement is occasionally heard among railroad men who ought to know better that small particles of abrasive from grinding wheels adhere to ground metallic surfaces. This statement has been absolutely refuted both by practical experience and by the most scientific physical tests. It is an understood fact that the success of many automobile manufacturers has been due to their ability to machine gasoline motor parts accurately and quickly on grinding machines. Many of these parts have ground bearings and their long life, when properly lubricated and adjusted for wear, affords ample proof that abrasive does not adhere to ground surfaces in such a way as to cause undue wear.

But it is not necessary to go to the automotive field for an illustration of the possibility and even economic necessity of grinding bearing surfaces. Many of the largest railroads in the country grind piston rods, valve stems, guides, crank pins, new driving axles, and in some cases car journals. No harmful results have followed the grinding of these parts and in fact the general tendency is to increase the life of the part. It is readily apparent that with a grinding machine properly adjusted and operated, the accuracy of a ground cylindrical surface exceeds the accuracy of a turned and rolled surface. The time required for the operation is less and, owing to the greater accuracy, the journal will have a longer life.

Not only has experience demonstrated the value of grinding for all sorts of bearing surfaces, but, as previously indicated, scientific experiments have failed to show any objections to this practice. Recently, samples of the surfaces of certain ground cylinders were submitted to the research laboratory of a prominent grinding machine company for examination. The findings of the investigators cannot be better expressed than by quoting the laboratory report: "The first examination of the sample submitted was made by using the highest magnification possible with a binocular microscope. This examination did not show the presence of any vitreous grain inserted in the metal. Frequently small pits were found but these contained no abrasive and are undoubtedly small blow holes in the metal.

"One-half of the sample was then dissolved in a one to one hot hydrochloric, plus five per cent sulphuric acid mixture. It was then filtered and washed with hot dilute hydrochloric acid, after which the residue was dried and examined microscopically for the presence of silicon carbide. No trace of this product could be found.

"The other half of the sample was polished on a small felt wheel coated with crocus in order to remove the finer scratches. The surface was then examined in reflected light with a metallographic microscope. No particles resembling abrasive were found. A portion of this polished surface was then etched with a five per cent nitric acid solution and again examined. Nothing was found which would indicate abrasive particles.

"We are therefore led to the conclusion that at least as far as the sample submitted is concerned there was no abrasive embedded in the surface of the metal."

Not only does every evidence point to the fact that abrasive is not embedded in ground surfaces, but these surfaces are smoother than can be obtained by any other method. Comparative microphotographs of ground and the most carefully reamed cylinders show that the latter are comparatively rough. In view of these investigations, it is evident that the prejudice against the use of grinding machines in railroad shops due to the supposed embedding of abrasive particles in ground surfaces, is unwarranted and railroad shop men should not allow this argument to deter them from using their influence wherever possible for furthering the installation of grinding machines, thereby effecting important economies by reduced maintenance and operating costs.

Prepare Now for Future Machine Tool Needs

Questions in connection with labor rates have commanded the attention of railroad motive power officers for some time and while rates have been reduced, it is not probable that they will again reach those prevailing before the war. In railroad work, as well as in manufacturing, the labor rate is not the only factor and frequently is not the largest factor in determining the cost of doing a certain piece of work. Other vital elements are the efficiency of labor and the facilities provided for doing the work. The big thing that should appeal to everyone in authority is the final cost of the job and not the labor rate. It is the duty of those responsible to see that the labor which they direct is used efficiently. Avoidance of waste in the use of labor in the shop requires the furnishing of adequate modern machinery properly equipped with tools and fixtures. During this period of business depression, master mechanics and shop foremen should take the occasion, as so many manufacturers are doing, to look into their entire shop equipment thoroughly and systematically in order to determine where the lack of proper tools will hold back production when the demand comes again—as come it surely will—and where the continued use of old machinery will add unnecessarily to the cost of turning out work over what it would be if modern machine tools were substituted.

There comes a time when economy demands that equipment be consigned to the scrap pile. Many machine tools that were used with fairly satisfactory results under labor conditions which prevailed a few years ago, can no longer be continued efficiently in service under present labor rates. When a weak spot is found, investigate what could be done with improved equipment, what type of machine is most suitable, the cost of the machine and its probable capacity for the work in mind. Even though no appropriation may be available at present or for some time to come, the man who knows what is needed, what the cost will be and what would be the probable results accomplished, is in a position to present facts which will enable him to obtain what he needs when the right time comes.

The Modern Driving Wheel Lathe

Many specialized machine tools have been developed for railroad shops and of these tools probably none has reached a more nearly perfected state than the driving wheel lathe. At least that is the impression gained by comparing recent models with wheel lathes made twenty or more years ago. There can be nothing but admiration for the powerful, high-production, conveniently operated machines, now used for turning locomotive driving wheel tires. True, the modern wheel lathe is an expensive machine, costing in the neighborhood of $20,000, and therefore not suitable for use in shops where only a small volume of work must be handled. The machine must be kept in operation a considerable proportion of the time, otherwise interest on the investment and depreciation charges will overbalance labor savings and economies resulting from modern improvements. Within reasonable limits, wheel lathe work should be concentrated at one point where a high production machine can be operated in two or more shifts, thereby proportionately increasing its possible savings.

As with all other questions, however, there is more than one side to this one. The modern wheel lathe is practically three machines in one and, when not used for turning tires, can be employed turning journals, facing hub plates, or quartering wheel centers. The fact that all of these operations can be performed on the same machine greatly extends the field of usefulness of that machine and enables it to be economically installed in far smaller shops than would otherwise be the case.

Modern wheel lathes are designed to stand all the severe usage encountered in turning the largest driving wheel tires and they force high speed lathe tools to the limit when cutting through tire treads hardened by slipping. Driving wheel lathes, made within the past few years, will turn a pair of the largest tires every hour on the average, including the time of setting up. By the use of high speed roughing tools, all excess material on a worn tire tread can be removed at one cut, whether it be ¼ in. or ¾ in. thick. The use of forming tools with ready means for changing from one tool to the other also enables accurate flange and tread contours to be machined quickly and with a minimum of physical effort.

Solid high speed lathe tools have been successfully eliminated in many modern railroad shops by substituting toolholders with high speed tool bits. Perhaps the main advantage of the latter practice is that so much money does not have to be tied up in solid high speed steel tools. The next advantage, and one which should not be overlooked, is the greater ease in grinding. A lathe operator will think twice before taking a pair of heavy solid lathe tools to the grinder and the tendency is to put off grinding as long as possible. With easily removable, high speed steel tool bits, however, there is every inducement to take them to the grinder frequently for touching up the top surfaces, because this requires no particular physical effort and greatly improves the cutting qualities of the tool, and consequently the production of the machine.

It is the duty of railroad mechanical officers to realize the possibilities of modern wheel lathes and make sure that antiquated, inefficient machines are not being used at points where the volume of work will pay handsome returns on the first cost of a new, high-power machine.

Getting Back to Normal

Ever since the slump in traffic occurred last fall, the railroads have been making a desperate struggle to bring their expenses back to a reasonable basis as compared with their earnings. There has been some slight improvement in recent months, but the definite turn for the better was expected to occur on July 1, when the new wage scale went into effect. Reports of earnings and expenses are slow in coming in and it will be impossible to tell for some time just what effect the reduction of wage rates will have on the net earnings. However, it is evident that the roads are looking for a better showing as maintenance work, which has been so severely curtailed, is now being resumed and efforts are being made to get the equipment in better condition.

Perhaps the most important factor in the railroad situation at the present time is the condition of freight cars. With 15.9 per cent in bad order on July 15, it is essential that repairs should be speeded up to put the equipment in condition to carry traffic, as the steady increase from week to week indicates that there will soon be business offered which the railroads will be unable to handle if cars are not in serviceable condition. Every mechanical department officer is interested in seeing a reduction in the number of bad-order cars. The railroads would like to get their rolling stocks back in normal condition, but the extent to which repairs can be carried on depends on the revenue that is available. Very large amounts will be needed to repair the heavy bad-order cars that are now setting on side tracks. In the first six months of this year, the heavy bad-order cars increased 139,193. It has been estimated that the average cost of repairs for these cars would be $1,100 and at this rate it would require $153,000,000 to make up the deficiency in freight car repairs that accumulated in the six months. This is almost one-fourth as much as was spent for maintaining freight cars during the entire year 1920. Even if this extra charge was spread out over a year, it would be difficult for the rail-

roads to meet it. It is evident that getting the percentage of bad-order cars back to normal will be a long, hard process and little progress will be made unless the job is tackled promptly and vigorously. Some roads are apparently deferring action until they can see definitely the results of operation during July. It is encouraging to note that others have put on full forces in the shops and are showing their confidence in the future by making contracts for repairing a large number of cars.

NEW BOOKS

The Engineering Index, 1920. 586 *pages,* 7 *in. by* 9½ *in. Published by The American Society of Mechanical Engineers,* 29 *West Thirty-ninth street, New York.*

The Engineering Index which was published from 1892 to 1917, inclusive, by the Engineering Magazine Company and since then by the American Society of Mechanical Engineers, has for many years been recognized as the standard reference index to current engineering literature, and is practically indispensable to those who have frequent occasion to look up articles which have been written on subjects in this field. The completeness of the index is shown by the fact that the volume for the year 1920 covers nearly 14,000 articles from some 700 engineering and technical publications, together with society proceedings. Most of these are in English, but the more important articles in French, German and other languages are included also. The subject matter is arranged in alphabetical order with convenient main and sub-heads and gives a concise description of the substance of each article. The railway field is well covered and includes references to articles on management, operation, construction, maintenance, electrification, signalling, terminals, stations, freight handling, yards, track, maintenance of way, shops, locomotives and cars.

Fuel Economy on Locomotives. 51 *pages;* 3¾ *by* 5¾, *cloth backed paper binding. Published by the American Railway Association, V. R. Hawthorne, Secretary, Mechanical Division,* 431 *South Dearborn street, Chicago.*

The need for a manual of firing practice and of instructions in the principles of fuel economy for locomotive enginemen and firemen has long been recognized. Early in its history the International Railway Fuel Association gave considerable attention to this subject and at the 1912 and 1914 conventions laid the foundation for such a manual which it was proposed later to develop more fully. The first actual results, however, other than the development of such manuals by a few individual railroads, was accomplished by the adoption of the report of the Committee on Fuel Economy of the American Railway Master Mechanics' Association as recommended practice following the 1915 convention of that organization. This manual has stood as the recommended practice of the Master Mechanics' Association and its successor, the Mechanical Division of the American Railway Association, until the revision which was made and adopted by the Mechanical Division in 1920, to be followed by the further revision effected by the Joint Committee on Fuel Conservation of the Operating, Mechanical, and Purchases and Stores divisions this year. The principal revisions are the elimination of the text references to and the illustrations of cross firing and the addition of material concerning the proper firing of anthracite coal and fuel oil, the bringing up to date of the special instructions for the operation of superheater locomotives and the addition of about 15 pages of general information largely dealing with locomotive conditions affecting fuel economy, a small part of which is of more interest to roundhouse forces than to the engine crews and might, therefore, not improperly be omitted from a discussion of the subject intended primarily for distribution among enginemen and firemen. The book is well bound for pocket use, is well illustrated with colored plates showing various firebox conditions affecting proper combustion, and altogether is a material improvement over its predecessor. It is furnished by the association to members in lots of 100 copies or more for $20 per hundred, in lots of 50 copies for $12.50 and in less than lots of 50 copies at 30 cents each. Single copies are 60 cents each to non-members. The book will be of particular interest to those roads that have not already developed manuals of their own and any railroad that desires special printing on the cover or title page or wishes to incorporate these rules in a more extensive book in which are included special rules to meet local conditions, may arrange for such special printing.

Engineering Instruments and Meters. By Edgar A. Griffiths. 360 *pages illustrated,* 7 *in. by* 10 *in. Bound in cloth. Published by D. Van Nostrand Company, New York.*

Engineers in the course of their work usually become familiar with the commoner measuring instruments, but very few men have a thorough knowledge of all the types used even for the measurement of a single quantity. Problems involving careful measurement occur frequently in the shop as well as in the laboratory, and a knowledge of the basic principles of various measuring instruments, their field and their limitations is therefore a valuable asset. The author has treated briefly a great number of instruments, in many cases giving a simple exposition of the theory on which they are based. The object has been to enable the reader to choose the instruments best suited for various requirements.

Many of the types of apparatus described are generally regarded as applicable only to work in the scientific laboratory, but as pointed out in the preface, these are introduced because of novel features which will probably be incorporated in appliances used for industrial purposes. The chapters treat of the measurement of length, screw threads, area, volume, velocity force and mass, work, and temperature. Of particular value from the practical standpoint are the sections devoted to the measurement of screw threads and to pyrometers. The wide scope of the book makes it especially valuable to those engaged in testing work.

Handbook of Standard Details. By Charles H. Hughes. Leather, 312 *pages,* 4¾ *in. by* 7¼ *in. Published by D. Appleton & Co., New York.*

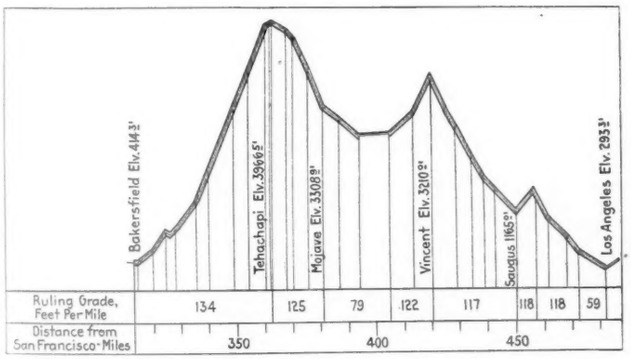
Although many handbooks are available and have proved to be of material assistance to engineers and designing draftsmen, this new work will undoubtedly be found a valuable addition for those engaged in the design of machinery or mechanical apparatus. The book, which is somewhat different in its scope from any other handbook, consists of a compilation of standard types of details of materials and manufactured parts used in machinery and engineering construction, together with drawings and tables giving dimensions, sizes, weights and other information gathered from American manufacturers of machine tools and other devices. The book is divided into convenient sections covering such subjects as the preparation of drawings, with such geometrical constructions as are commonly found necessary; fastenings, such as bolts, nuts, screws, nails, keys, gibs, pins and cotters; power transmission, including shafting and accessories, chain drives, belting and rope transmission; pipe, tubing and fittings, including iron, brass and copper; rope and chain fittings; miscellaneous details of machine tool and engine parts; structural details, including shapes, plates, beam connections and riveted joints, together with a section of miscellaneous tables of measures, weights and equivalents most commonly needed.

Waiting to Take a Train Over the Mountains

Heavy Locomotives for the Southern Pacific

Pacific Type Handles 11 Passenger Cars on 1.5 Per Cent Grade—New 2-10-2 Type Increases Tonnage

DURING the early part of the year, the Southern Pacific received from the Baldwin Locomotive Works 15 locomotives each of the 4-6-2 and 2-10-2 types. The 4-6-2 type was built particularly for use on heavy passenger trains between Ogden, Utah, and Carlin, Nev.; and the 2-10-2 type on heavy freight trains between Los Angeles, Calif., and Bakersfield.



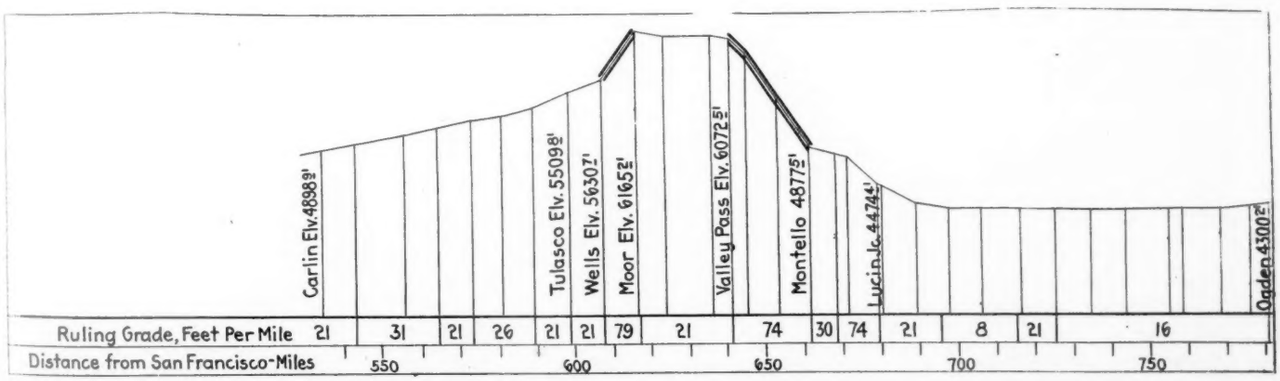
Profile of Road Between Bakersfield, Calif., and Los Angeles

Between Ogden and Carlin, a distance of 247 miles, the maximum grade is 1.5 per cent, 10 miles of which is encountered going east, and 20 miles going west, the remaining grades varying from 0.15 per cent to 0.6 per cent. These 4-6-2 type locomotives are capable of handling on this district, without helper service, a passenger train consisting of 11 cars, including Pullman cars, which weighs 875 tons. Locomotives of the lighter design of the 4-6-2 type, which the new locomotives displace, require helpers when going west from Montello to Valley Pass and from Wells to Moor going east.

Between Los Angeles and Bakersfield, a distance of 171 miles, there are 64 miles over grades of from 2.2 per cent to 2.37 per cent going west, and 73 miles over grades of from 2.23 per cent to 2.54 per cent going east, the remaining grades varying from 1.0 per cent to 1.5 per cent. The tonnage hauled by these 2-10-2 type locomotives is 1,005 tons going west, and 865 tons going east, or about 13 per cent over that handled by the former lighter 2-10-2 type locomotives.

The specifications and general designs for these locomotives were worked up under the supervision of George McCormick, general superintendent of motive power, and F. E. Russell, assistant mechanical engineer, the designs being completed and details worked out by the builders.

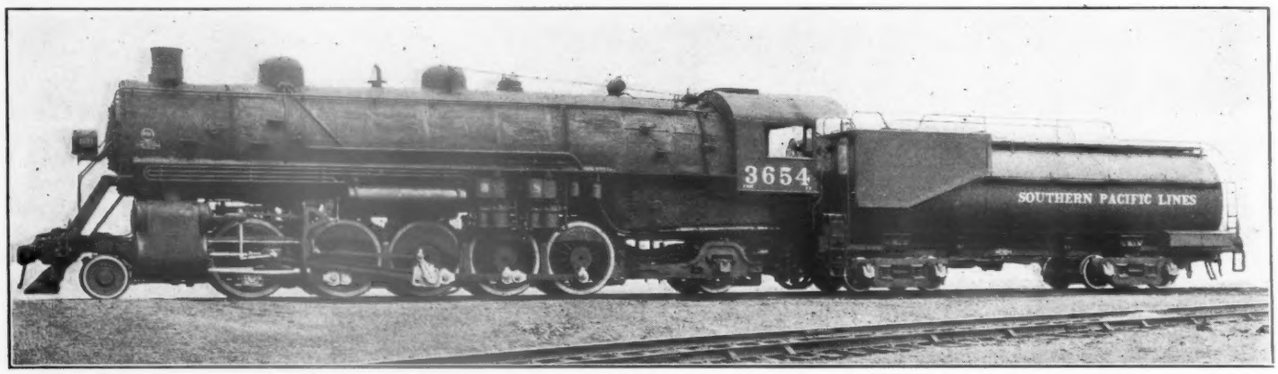
The 4-6-2 type locomotives have a rated tractive effort of 43,660 lb. with 180,000 lb. on drivers, the ratio of adhesion being 4.12. The total equivalent heating surface is 4,605 sq. ft. or 1 sq. ft. for each 9.5 lb. of tractive effort, this ratio



Profile of Road Between Carlin, Nev., and Ogden, Utah

indicating good steaming capacity. The boiler is of the extended wagontop type with a wide firebox placed back of the drivers and over the rear trucks. A combustion chamber 3 ft. long extends forward into the boiler barrel, and the tubes have a length of 18 ft. The superheater consists of 40 units and has a superheating surface of 836 sq. ft. The cylinders have a stroke of 30 in., which is a departure from the usual practice in passenger locomotive design. The long stroke was based on the results of numerous tests of locomotives with superheaters made by the Southern Pacific, which justified the use of the longer stroke with superheated steam. The boiler is of the straight top type with a firebox 90 in. wide placed over the rear truck. The combustion chamber is 5 ft. 4 in. long, and the tubes have a length of 21 ft. The cylinders have a stroke of 32 in. and lateral motion driving boxes are provided on the first pair of drivers.

Among the specialties applied to both types of these locomotives are Commonwealth cast steel tender frames, four-wheel equalizing swing motion tender trucks, Delta type trailing truck frames, radial buffers, Unit type safety bars, Ragonnet power reverse gears, extended main driving boxes and Nathan non-lifting injectors. A complete installation



2-10-2 Type Locomotive for Handling 1,000 Tons on 2.4 Per Cent Grades

The performance of these 4-6-2 type locomotives since going into service has proved that no mistake was made in adopting a longer stroke for passenger locomotives.

The 2-10-2 type locomotives have a rated tractive effort of 75,150 lb., with 297,300 lb. on drivers, the ratio of adhesion being 3.96. The total equivalent heating surface is 6,933 sq. ft., or 1 sq. ft. for each 10.8 lb. of tractive effort, this ratio likewise indicating excellent steaming capacity. of F.B.C. flexible staybolts is made in the breaking zone of the firebox and in the combustion chamber around the belly of the boiler.

Both types are oil burners and are equipped with Walschaert valve gear with the link block in the bottom of the link in forward motion, the gear being so arranged as to give equal cut-off at 55 per cent of the stroke. The lead is ¼ in., lap 1¼ in., exhaust clearance ⅛ in., and valve travel for

COMPARISON OF NEW AND OLD DESIGNS OF 4-6-2 AND 2-10-2 LOCOMOTIVES

	4-6-2 Type locomotives		2-10-2 Type locomotives	
Date built	1912	1921	1917-19	1921
Tractive effort	29,920 lb.	43,660 lb.	65,300 lb.	75,150 lb.
Cylinders	22 in. by 28 in.	25 in. by 30 in.	27½ in. by 32 in.	29½ in. by 32 in.
Weights:				
Total engine	220,900 lb.	297,800 lb.	348,000 lb.	385,900 lb.
On driving wheels	141,400 lb.	180,000 lb.	273,000 lb.	297,300 lb.
On leading truck	38,000 lb.	59,700 lb.	29,000 lb.	29,800 lb.
On trailing truck	41,500 lb.	58,100 lb.	46,000 lb.	58,800 lb.
Engine and tender	359,000 lb.	519,800 lb.	521,460 lb.	607,900 lb.
Wheel base, driving	13 ft. 4 in.	13 ft.	22 ft. 6 in.	22 ft. 10 in.
Wheel base, total	33 ft. 4 in.	35 ft. 6 in.	41 ft. 6 in.	42 ft. 4 in.
Wheel base, engine and tender	63 ft. ¼ in.	75 ft. 9½ in.	80 ft. 2½ in.	82 ft. 7½ in.
Ratios:				
Weight on drivers, tractive effort	4.72	4.12	4.18	3.96
Equivalent heating surface*—Grate area	72.3	65.4	93.8	84.1
Per cent firebox heating surface to evaporative surface	6.34	8.41	7.34	7.79
Per cent superheating surface to evaporative surface	20.25	24.95	21.8	23.6
Total evaporative surface—Volume of cylinders	222.8	196.7	202.5	202.4
Wheels:				
Driving, diameter over tires	77½ in.	73½ in.	63½ in.	63½ in.
Driving, thickness of tires	3¾ in.	3¾ in.	3¾ in.	3¾ in.
Driving journals, main	10 in. by 12 in.	12 in. by 22 in.	12 in. by 22 in.	13 in. by 22 in.
Driving journals, front	9 in. by 12 in.	11 in. by 13 in.	10 in. by 20 in.	11 in. by 20 in.
Driving journals, others	9 in. by 12 in.	11 in. by 13 in.	10 in. by 13 in.	11 in. by 13 in.
Engine truck wheels, diameter	33 in.	36 in.	33 in.	33 in.
Engine truck journals	6 in. by 10 in.	7 in. by 12 in.	6 in. by 12 in.	6 in. by 12 in.
Trailing truck wheels, diameter	45½ in.	51½ in.	45½ in.	45½ in.
Trailing truck journals	8 in. by 14 in.	9 in. by 14 in.	8 in. by 14 in.	9 in. by 14 in.
Boiler:				
Style	Straight Top	Ext. Wagontop	Ext. Wagontop	Straight Top
Working pressure	200 lb.	200 lb.	200 lb.	200 lb.
Outside, diameter, first ring	70 in.	78 in.	82 7/16 in.	90 in.
Firebox, length and width	108 in. by 66 in.	120⅝ in. by 84 in.	120⅛ in. by 75¼ in.	132 in. by 90 in.
Tubes	182—2 in.	193—2¼ in.	279—2 in.	261—2¼ in.
Flues	24—5⅜ in.	40—5½ in.	40—5⅜ in.	50—5½ in.
Tubes and flues, length	20 ft.	18 ft.	20 ft. 6 in.	21 ft.
Heating surface, tubes and flues	2,571 sq. ft.	3,069 sq. ft.	4,130 sq. ft.	4,722 sq. ft.
Heating surface, firebox	175 sq. ft.	282 sq. ft.	327 sq. ft.	399 sq. ft.
Evaporating heating surface, total	2,745 sq. ft.	3,351 sq. ft.	4,457 sq. ft.	5,121 sq. ft.
Superheating surface	556 sq. ft.	836 sq. ft.	972 sq. ft.	1,208 sq. ft.
Equivalent heating surface,* total	3,579 sq. ft.	4,605 sq. ft.	5,915 sq. ft.	6,933 sq. ft.
Grate area	49.5 sq. ft.	70.4 sq. ft.	63 sq. ft.	82.5 sq. ft.
Tender:				
Tank	Cylindrical	Cylindrical	Cylindrical	Cylindrical
Water capacity	7,000 gal.	12,000 gal.	10,030 gal.	12,000 gal.
Oil capacity	2,940 gal.	4,000 gal.	3,120 gal.	4,000 gal.

*Equivalent heating surface equals total evaporating heating surface plus 1.5 times the superheating surface.

the 4-6-2 type 6½ in. and for the 2-10-2 type, 7 in. These valve events were decided upon from experiments made during the locomotive tests above referred to, proving to be the most efficient of the numerous combinations tried.

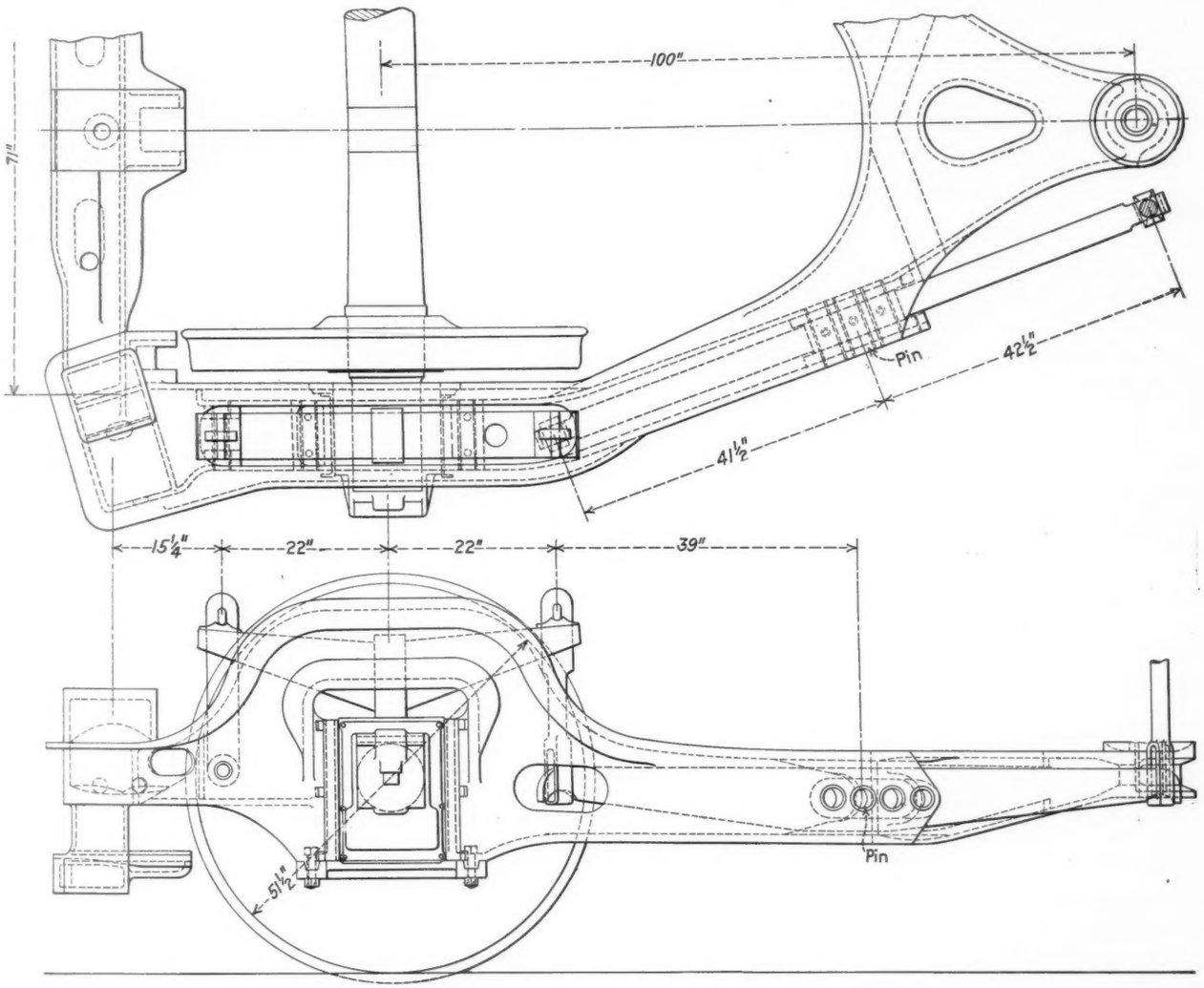
The counterbalance is designed to balance only 50 per cent of reciprocating parts and to produce a dynamic augment at diameter speed not exceeding 50 per cent of the static wheel load. The reciprocating parts are very light, the piston heads being of the built-up type with cast iron bull-rings, and the piston rods of open-hearth steel, heat-treated, and hollow bored. The main and side rods are also of very light design, all being of I-section except the side rods on the 2-10-2 type locomotives, which are rectangular. All driving axles and main and forward crank pins are made of open-hearth heat-treated steel, and are also hollow bored. Constant resistance leading trucks are applied to both types of locomotives.

The trailing trucks on the two types of locomotives are interchangeable and are equalized with the drivers by means of equalizing beams which are fulcrumed on the truck frame. With this arrangement, which is a new departure for this type of truck, the load is transferred to the truck frame at the radius bar pin and through two sliding bearings placed on the right and left sides back of the truck wheels.

In both the 4-6-2 and the 2-10-2 locomotives, the weight on the trailing trucks is approximately 58,000 lb. The weight at the radius bar pin of the trucks is about 45,000 lb. and on each of the pads back of the wheels, 20,500 lb. The load at the equalizer fulcrum pin is a little over 28,000 lb. and between 14,000 lb. and 15,000 lb. on each hanger. In previous designs of the Delta truck, the weight was not equalized between the trailing wheels and the driving wheels.

The tenders, which are of the Vanderbilt type, are unusually large, having a capacity of 12,000 gal. of water and 4,000 gal. of oil. The tender trucks are of the equalized type with journals 6½ in. by 12 in.

The accompanying tabulation shows the principal dimensions, weights and ratios of the two new types, and, for comparison, of lighter locomotives of the same types which were superseded by the new power between the points mentioned.



Trailing Truck With Equalizer Between Trailing and Driving Wheels

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DIESEL LOCOMOTIVES FOR INDUSTRIAL SERVICE.—Benz & Company of Mannheim, Germany, has brought out a line of Diesel locomotives especially designed for industrial purposes. The locomotives work without compressors and hence are really semi-Diesels, the fuel being delivered by the feed pump direct into the cylinders. The engine is started by means of the slightly compressed air stored in a cylinder during the working of the engine; the cylinder is sufficiently large to admit of restarting several times on one charge. The locomotives are built in sizes up to 200 hp. and are arranged for three speeds.

Maintenance of Air Operated Auxiliaries*

A Big Net Saving Effected by the Application of Air Brake Association Condemning Limits

THE report of the committee submitted last year† was intended to be final, but the report was received with so much discussion that the committee was continued with a view to attaining the following objects:

1. To obtain more complete and representative data concerning the air consumption of locomotive auxiliary devices.
2. To follow up, with the assistance of the Air Brake Association members, the use of the test code and determine its weak points with a view to suggestions for revision of its method or the limits imposed.
3. To devise a convenient system for recording and reporting a maintenance program both from the standpoint of the cost and the value of benefits derived.
4. To obtain reliable and accurate data of the cost factors involved in a maintenance program for air operated locomotive auxiliary devices.
5. To simplify the practical application of the test code to the work of testing auxiliary devices on steam locomotives.
6. To investigate the condition of air operated auxiliary devices on electric locomotives.
7. To devise a method of test and formulate a test code which will be adequate to determine the condition of air operated auxiliary devices on electric locomotives.
8. To determine test limits which can be used to condemn electric locomotive auxiliary devices out of service for repair or replacement.

Form No. 1 AUXILIARY DEVICES TEST REPORT

Railroad N.Y.C. (Lines West) Location Elkhart Date 6-1-20

Loco. No. 2614 Class L-1-c-s Type of Comp. W.A.B. 8½" c.c. 150 Sheet 1

Main Reservoir Working Pressure 140 Time Required by Test 1 hr. 10 min.

SERVICE ~~REPAIR~~ TEST

DEVICE	THREE TESTS: Compressor Speed: Single Stroke per Min.: Leakage only	Compressor Speed: Single Stroke per Min.: Leakage plus Orifice	Compressor Speed: Single Stroke per Min.: Leakage plus Device	COMPUTATION OF RESULTS: Comp. Strokes per Min. due to Orifice only	Comp. Strokes per Min. due to Device only	Percentage of Strokes: Column 6 Column 5	Disposition
1	2	3	4	5	6	7	Disposition
Bell Ringer On	45	157	72	112	27	24.1	R
Fire Door Open			51		6	5.35	OK
Fire Door Closed			54		9	8.03	L.R.
Cylinder Cocks Open			56		11	9.82	OK
Cylinder Cocks Closed			52		7	6.25	OK
Reverse Gear 1/4 Forward			76		31	27.6	R
Sander (Per each 3/32" dia. nozzle)			58-57		13-12	11.6-10.7	OK
Ash Pans Open			Not Equipped				
Ash Pans Closed							
Water Scoops Lowered			72		27	24.1	L.R.
Water Scoops Raised			83		38	33.9	L.R.
Coal Pusher On			Not Equipped				

Disposition Symbols (O.K. = Passed into service without repairs. R. = Replaced with O.K. device and sent to shop. L.R. = Local repairs without removing device.

REMARKS Repaired leak in fire door pipe connection. Time 20 min. Replaced water scoop cylinder packing. Time two men 35 min.

Tester John Smith

Fig. 1—Form No. 1, Auxiliary Devices Test Report on Which Record of Test Results Is Made

The committee prepared a small pamphlet to cover the code for testing air operated auxiliary devices on steam locomotives. This pamphlet was published by the Air Brake Association, and contained an illustrated plan for making auxiliary device test reports so as to cover not only actual test results, but all the cost factors of maintenance as well. This plan was worked out so that complete reports could be made with the use of only three different forms.

The object of preparing the pamphlet was to get this information in convenient form to send out, with requests that maintenance programs be initiated and the results reported to the committee as outlined. It was recognized that if reliable maintenance cost figures were to be secured it would be necessary to obtain them from several localities, and the work would have to be done in systematic and uniform manner, so that the data would be comparable and the averages truly indicative of general conditions.

The committee realized that these requests represented a very large amount of work and expenditure, but it was their judgment that in every instance where the request was complied with the actual benefits derived would more than offset expenses and effort expended on it.

Form No. 2.

AUXILIARY DEVICES TEST REPORT

Railroad N.Y.C. (Lines West) Location Elkhart

SUMMARY OF COST DATA SHEET

Auxiliary Device Reverse Gears Sheet 1

Loco. No.	Date	Disposition	COST: Testing Labor	COST: Shop Repairs Labor	COST: Shop Repairs Material	COST: Total	Remarks: Nature of Repairs
1	2	3	4	5	6	7	8
2614	6-1-20	R	$ .10	$ 3.50	$ 2.20	$ 5.80	Overhauled.
2593	6-3-20	L R	.10	.40	.10	.60	Repacked Stuffing Box
2597	6-5-20	L R	.25	.30	.20	.75	
2603	6-5-20	OK	.20	—	—	.20	
2622	6-7-20	OK.	.15	.30	.10	.55	
2625	6-8-20	L R	.20	.55	.10	.85	Repacked Stuffing Box
2608	6-9-20	L R	.14	.25	.25	.64	
2599	6-10-20	L R	.30	.35	.15	.80	
2618	6-14-20	R	.10	2.75	2.25	5.10	Overhauled
2585	6-15-20	L R	.15	.45	.25	.85	
2627	6-15-20	L R	.10	.60	.20	.90	
2651	6-17-20	OK	.15	—	—	.15	
720	6-21-20	OK	.15	—	—	.15	
355	6-23-20	R	.30	2.75	2.20	5.25	Overhauled
2590	6-25-20	L R	.10	.25	.15	.50	
2642	6-28-20	L R	.15	.30	.25	.70	
5169	6-29-20	L R	.25	.40	.10	.75	
2588	6-30-20	OK	.28	—	—	.28	Repacked Stuffing Box
TOTALS						$ 24.82	

Inspector J R Brown

Fig. 2—Form No. 2, Summary Record of Tests of Each Device on Which Cost of Testing and Repairs Is Entered

Auxiliary Devices Test Report

The three forms were prepared with the object of simplifying the work of recording the data required. They were designated as Forms No. 1, No. 2 and No. 3.

Form No. 1 is intended for the use of the workman or tester in recording the data of the tests as made on the engine and to record the disposition of the devices as determined by the result of the test data computations. All tests were classi-

*Abstract of a report presented at the open meeting of the Executive Committee of the Air Brake Association, held at the Hotel Sherman, Chicago, May 3, 1921.

†See the *Railway Mechanical Engineer* for June, 1920, page 395.

fied as either "Service" or "Repair" and were to be reported on separate sheets with the kind of test indicated as described. When repairs or replacements were made as a result of service tests, repair tests to check the condition of devices going into service were to be made and reported.

It is recommended that service tests of auxiliary devices be made at regular intervals with the time of service between tests not more than three months.

Form No. 2 was intended for making a monthly summary of the maintenance cost for each kind of auxiliary device maintained. The data for this sheet are obtained from the test sheets submitted by the tester and the repair shop cost department.

The disposition symbols given at the bottom of Form No. 1 indicate the disposition of tested devices in each case. When

Form No. 3.

AUXILIARY DEVICES TEST REPORT.

Railroad N.Y.C. (Lines West) Location Elkhart

SUMMARY AIR CONSUMPTION DATA SHEET

Auxiliary Device Reverse Gears Sheet 1

TABLE OF COST FACTORS FOR COLUMN 8.

Type of Compressor	WAB CO. 9-1/2"	WAB CO. 11"	WAB CO. 8½CC 120	WAB CO. 8½CC 150	NYAB CO. 2-a	NYAB CO. 6-a	NYAB CO. 5-b
Cost Factor	.011	.0132	.0073	.0105	.0092	.0128	.0136

METHOD - Column 9 = $\frac{\text{Column 7 x Column 8 x (Column 4 + 14.7)}}{60 + 14.7}$

Loco. No.	Date	Class	Main Reservoir Working Pressure	Percentage of Strokes: Service Test	Repair Test	Saving	Cost Factor	Value of Air Saved per Day of Service
1	2	3	4	5	6	7	8	9
2614	6-1-20	L-1-C	140	27.6	3.0	24.6	.0105	$0.535
2593	6-3-20	"	"	20.0	5.0	15.0	"	.326
2597	6-5-20	"	"	31.0	2.4	28.6	.0136	.805
2603	6-5-20	"	"	13.5	1.5	12.0	"	.338
2622	6-7-20	"	"	12.6	2.0	10.6	"	.298
2625	6-8-20	"	"	32.5	3.0	29.5	.0105	.641
2608	6-9-20	"	"	24.2	2.7	21.5	"	.467
2599	6-10-20	"	130	27.5	1.8	25.7	"	.523
2618	6-14-20	"	"	22.4	4.6	17.8	.0136	.469
2585	6-15-20	"	"	25.5	2.1	23.4	.0105	.477
2627	6-15-20	"	140	30.5	3.0	27.5	"	.598
2651	6-17-20	"	"	18.6	2.5	16.1	.011	.367
720	6-21-20	Pony	"	15.5	1.6	13.9	"	.317
1355	6-23-20	Moller	"	30.7	3.0	27.7	.0105	.602
TOTALS								$6.762

Inspector J. R. Brown

Fig. 3—Form No. 3, Summary Record for Each Device on Which Value of Saving in Air Consumption Is Computed

the device is found O. K., the only cost is that required to cover the labor of testing. When the device is condemned but is made good by local repairs without removing the device from the locomotive, the cost includes the testing labor and in addition whatever labor was required to make the repairs plus cost of any material used. When the device is condemned and replaced by a new or repaired device, the cost includes the testing labor plus the average cost for overhauling the particular kind of device in the shop and the cost of the labor necessary to make the replacement.

Form No. 3 is similar to Form No. 2 in that it was intended to serve the supervising inspector for keeping a summary record of the amount saved as a result of the maintenance repairs provided for each kind of device. The computation of the value of compressed air saved was greatly simplified by the cost factors and method given in the heading of this sheet.

The cost factors to be used in Column 8 depend on the type of air compressor employed for the test in each case. They have been worked out on the basis of certain assumptions as follows. That the average working time of locomotives is six hours per day; that the boiler factor of evaporation is seven pounds of water per pound of coal; that the cost of coal on the tender is $2 per ton; that the compressor steam consumption in pounds per 100 cubic feet of free air compressed is 68 for Westinghouse 9½-in. and 11-in. compressors and New York 2-a compressor, 24 for the Westinghouse 8½-in. c.c. compressor, 56.3 for the New York 6-a compressor and 44.7 for the New York 5-b compressor.

The actual computation of the factors can best be illustrated by the following example in which the 9½-in compressor factor is derived:

6x60 = Total minutes per day of service.
7 = Factor of evaporation.
$2.00 = Price of coal per ton.
2,000 = Pounds per ton.
68 ÷ 100 = Steam consumption per cu. ft. of free air.
3 ÷ 9.5 = Cubic feet of free air per one per cent of compressor strokes saved.

Then—

$$\frac{6\times60\times68\times2.00\times3}{7\times100\times2000\times9.5} = .011$$

It has been pointed out that the above plan for computing the saving due to auxiliary device maintenance is based on the value of compressed air only. There are other factors, such as cost of water, wear on compressor plant, etc., but these have been omitted because to properly consider them would add more complication to the computations than is justified by the importance of these factors and because their omission is in the direction of placing the saving values on a more conservative basis.

Maintenance Cost Data

Complete reports, including cost factors, were received from three railroads, and one of these reports was analyzed to show how the information would apply to the system as a whole provided a maintenance program was carried out at all repair points. The summary and analysis follows.

On this railroad there are in service 878 bell ringers, 811 single unit and 67 double unit fire doors, or a total of 945, and 667 single unit and 209 double unit sanders, or a total of 1,087 of such devices. A summary of the results obtained by inspection and repairs is shown in Table I.

TABLE I—SUMMARY OF TEST REPORTS ON ONE RAILROAD

	Number tested	Average repair cost	Cost of air saved per device per six hours of service (coal at $2 per ton)	Corrected cost of air saved (coal $3.531 per ton)
Bell ringers	47	$1.18	$.0483	$.0768
Fire doors	59	1.21	.0486	.0772
Cylinder cocks	3	.76	.1000	.159
Sanders	51	.62	.153	.2435

It is estimated that the actual hours of service per day for each device are three hours for the bell ringers, six hours for the fire doors and one hour for the sanders. The number of engines in actual service on this railroad averages about 85 per cent of the total number of engines, so that the average number of auxiliary devices in service each day is 746 bell ringers, 852 fire doors and 915 sanders. On this basis the savings effected by testing and repairing the devices have been computed and are shown in Table II.

TABLE II—SAVING PER YEAR EFFECTED BY REDUCING AIR CONSUMPTION OF AUXILIARY DEVICES TO WITHIN THE LIMITS PRESCRIBED IN THE TEST CODE

Device	Total saving by reduction of air consumption	Total cost of testing and repairs to devices	Net saving
Bell ringers	$10,450.00	$1,037.00	$9,413.00
Fire doors	24,007.00	1,142.00	22,865.00
Sanders	13,540.00	673.00	12,867.00
Totals	.....	$2,852.00	$45,145.00

These results clearly show the immense possibilities for greater economy in a properly directed and executed plan for maintenance. It is reasonable to assume that the unit repair

costs, which were determined by what it cost to repair a few long neglected devices, could be greatly reduced if the devices were handled in greater numbers and always given periodic attention.

The test code has been criticised because it is difficult for the tester to apply the condemning limits to the test results. The committee has devised a method whereby the condemning limits can be based on compressor strokes as shown in Table III. This table is greatly condensed and arranged so it can be printed or pasted on a card in a form convenient for the tester to carry with him. It is made up so as to cover all types of steam-driven air compressors, but in most cases the tester will only be required to deal with two or possibly three different types so that the size of the table can be very much reduced by omitting the data for the types of compressors not used. The limits as so defined are not absolutely accurate, but their application will yield results that will be quite satisfactory for the purpose intended. The use of this limit table need not conflict with the use of Forms No. 1, No. 2 and No. 3 for making auxiliary devices test reports.

TABLE III—AIR AUXILIARY DEVICES CONDEMNING LIMITS

Type of Pump*	W. A. B. Co., 9½ in.				W. A. B. Co., 11 in.			W. A. B. Co., 6½ in., 120			W. A. B. Co., 8½ in., 150			N. Y. A. B. Co., 2-a				N. Y. A. B. Co., 6-a				N.Y.A.B.Co., 5-b		
Pump strokes per minute due to orifice only	90	100	110	120	80	90	100	80	90	100	80	90	100	90	100	110	120	90	100	110	120	80	90	100
Bell ringers	9 to 11				6 to 8			4 to 5			3 to 4			10	12	13	14	6 to 8				4 to 5		
Fire door	14	16	17	19	11 to 13			7	8	9	5 to 6			18	19	21	23	10	11	12	14	7	8	9
Cylinder cocks, reverse gear and sander	28	32	35	38	21	24	27	14	16	17	9	10	12	34	38	42	46	21	23	25	27	14	16	17
Ash pan	43	47	52	57	32	36	40	20	23	25	14	16	18	52	57	63	68	31	34	37	41	20	23	25
Water scoop and coal pusher	57	63	69	70	42	48	53	27	31	34	19	21	24	69	76	84	92	41	45	50	54	27	31	34

*Device passes test if strokes made by pump due to device only are not more than values given.

Test Code Limits

During the past year's experience in the use of the test code, the committee gave considerable study to the leakage or air consumption limits prescribed by the code. These limits were presented to and adopted by the Association with the understanding that they were to be regarded as tentative and subject to revision. The committee is agreed that up to this time experience has shown that the limits of permissible rates of air consumption are much higher than can be justified from either the basis of repair costs or the basis of compressed air savings. This fact was very evident to most of the test code users, several of whom commented to that effect.

In the report submitted to this Association last year the code limits were defined and illustrated in terms of cubic feet of free air consumed per minute. It was thought that a better conception of the magnitude of the limits could be given if they were shown compared relatively on the basis of leakage area through the device.* It is the judgment of the committee that the code limits can and should be materially decreased.

Electric Locomotives

The most difficult feature in connection with the treatment of auxiliary devices on electric locomotives was the task of devising a suitable method for testing. The method and code devised for testing auxiliary devices on steam locomotives worked out in a very simple and convenient way because after adjustment of the apparatus the only observation necessary was the counting of the steam compressor strokes. The same plan could not be carried out for making auxiliary device tests on electric locomotives because of the totally different characteristics of the motor driven compressors and their method of control, but it was deemed desirable to follow the method of the steam locomotive tests as nearly as possible: It was decided to eliminate the compressor and base the observation on the time required for the auxiliary device to cause a given drop in main reservoir pressure. This method has the same advantages as the steam locomotive tests; namely, a minimum of test apparatus and only one observation, but it is somewhat more difficult to reduce the test observations to a form which will express the rate of air consumption in cubic feet of free air per minute. The test code has been given a trial in service and it has shown results which are both practical and dependable.

The committee does not deem itself qualified at this time to suggest a set of condemning limits for application to tests of auxiliary devices on electric locomotives. While the test code has been used sufficiently to fully demonstrate its practicability, our experience covers the testing of comparatively few locomotives and we do not have complete knowledge of the functions and importance of some of the auxiliary devices in question. The fixing of tentative and final condemning limits lies within the province of those members of the Association who are directly responsible for the operation of auxiliary devices on electric locomotives. They should have no difficulty in establishing limits after the code has been in use for a short time.

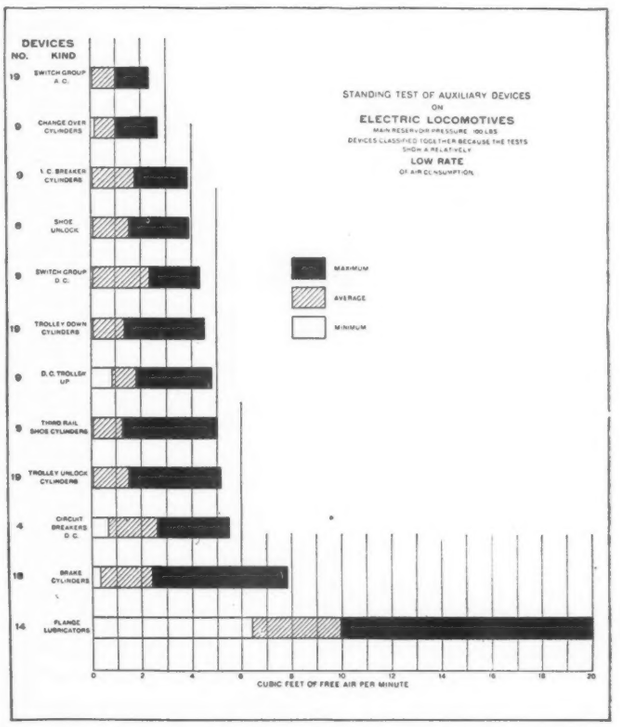

DEVICES
NO. KIND
19 SWITCH GROUP A.C.
9 CHANGE OVER CYLINDERS
9 I.C. BREAKER CYLINDERS
8 SHOE UNLOCK
9 SWITCH GROUP D.C.
19 TROLLEY DOWN CYLINDERS
9 D.C. TROLLEY UP
9 THIRD RAIL SHOE CYLINDERS
19 TROLLEY UNLOCK CYLINDERS
4 CIRCUIT BREAKERS D.C.
18 BRAKE CYLINDERS
14 FLANGE LUBRICATORS
STANDING TEST OF AUXILIARY DEVICES ON ELECTRIC LOCOMOTIVES
MAIN RESERVOIR PRESSURE 100 LBS
DEVICES CLASSIFIED TOGETHER BECAUSE THE TESTS SHOW A RELATIVELY LOW RATE OF AIR CONSUMPTION
MAXIMUM
AVERAGE
MINIMUM
0 2 4 6 8 10 12 14 16 18 20
CUBIC FEET OF FREE AIR PER MINUTE

Fig. 4—Air Consumption of Electric Locomotive Auxiliary Devices Which Showed a Relatively Low Rate

The standing tests made on electric locomotive auxiliary devices included a total of 346 devices on 49 locomotives belonging to three different railroad systems. When the data from these tests were computed and tabulated, it was noticed that the various types of devices could be classified as low or

*The report contained a chart comparing the orifice sizes equivalent to the leakage rates at the condensing limits, with an orifice ⅛ in. in diameter. The areas of these orifices have the following proportionate value of the area of the ⅛ in. orifice: bell ringers, 71 per cent; fire doors, 120 per cent; cylinder cocks, reverse gears and sanders, 237 per cent; ash pans, 357 per cent; water scoops and coal pushers, 476 per cent.

high depending on the rate of air consumption found. The data were, therefore, plotted according to this classification and are shown in Figs. 4 and 5, respectively.

General Discussion

It is essential whenever work is done to promote economy that an accurate record be kept or otherwise the work will be in danger of classification as unnecessary and will be cut off. The plan has been worked out so that with the use of only three forms it will be convenient to keep the record up to date and ready for making a complete report on short notice, or at stated intervals, such as monthly or quarterly. The executive officers of railroad systems who are responsible for the effi-

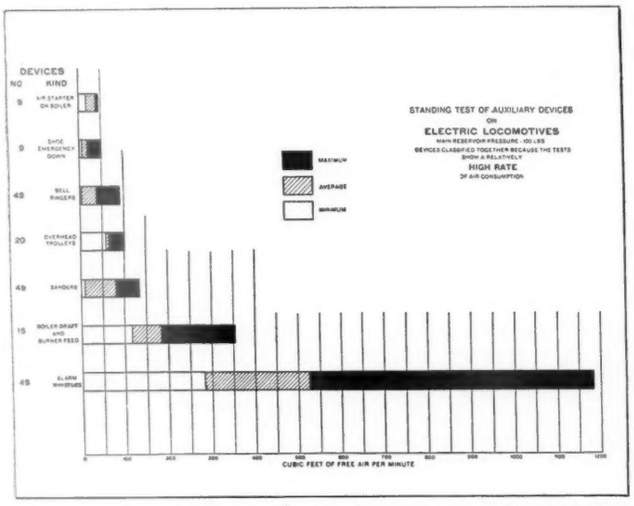


Fig. 5—Air Consumption of Electric Locomotive Auxiliary Devices Which Showed a Relatively High Rate

cient operation of locomotives are often too busy to appreciate the value of auxiliary device maintenance unless they can have access to a record which will give them at a glance the summation of repair costs compared to the benefits derived.

The maintenance programs which were reported according to the plan show results that would be hard to credit if it were not possible to check up the records by comparison. The tremendous margin for economy is more evident than it has been in any of the data submitted previously by this committee. The yearly saving of more than $45,000 for a railroad system that uses less than 1,000 locomotives is remarkable. Of course, this value is based on cost of testing and repairing all auxiliary devices at least once a year. It might be possible that the average need of repairs would prove to be more than once a year for each device. In such event, the savings figures would be reduced by the increased cost of repairs, but this reduction would not seriously affect the margin of saving. The figures show that the frequency of repairs could be increased to four times a year or once every three months for each device and still permit a saving of more than $36,000. It should be borne in mind that this saving does not take into account the large benefits derived in the way of more reliable and efficient auxiliary device operation. Locomotive failures and expensive delays are frequently chargeable to auxiliary devices when the latter are poorly maintained.

Standing tests show that the average condition of auxiliary devices on steam locomotives is far below the standard that should and can be maintained. Figures obtained from tests made this year are not much different from those presented in previous reports and they confirm all the original conclusions.

The electric locomotive auxiliary device tests indicate that many of these devices use much more air than should be required for the functions they perform. The consistently low minimum values of air consumption rate found on most types of devices show that their condition is about on a par with that of auxiliary devices on steam locomotives. It will be noted that very high rates of air consumption were observed for some of the devices; in fact, the larger of these values are much in excess of anything experienced in tests made on steam locomotives. The average rate for alarm whistles is more than 500 cu. ft. per minute, and the maximum on one whistle was as high as 1,180 cu. ft. per minute or about 25 times the nominal capacity of the C-60 compressor commonly used on electric locomotives. This rate is equivalent to an orifice ¾ in. in diameter and no doubt this whistle is like the one made famous by Mark Twain.

The report is signed by C. H. Weaver (New York Central), chairman; C. B. Miles, (Big Four), W. W. White (Michigan Central), and R. E. Miller, (Westinghouse Air Brake Company).

Pulverized Lignite as Locomotive Fuel

In a written discussion of the report of the Committee on Pulverized Fuel presented at the 1921 convention of the International Railway Fuel Association, W. D. Wood (Fuller Engineering Company) presented the following data relative to locomotive tests with pulverized North Dakota lignite.

An average analysis of this coal as mined, is as follows: moisture, 40.53 per cent; volatile, 27.05 per cent; fixed carbon, 27.37 per cent; ash, 5.05 per cent; B. t. u. value, 6,644.

After being in transit for about a month when received at Fullerton, this coal had a moisture content of approximately 33 per cent, which after unloading and being allowed to stand in the open for several days was further reduced to about 24 per cent. After being crushed, dried and pulverized, this coal showed a moisture content of 13.68 per cent, the volatile content being 41.02 per cent, fixed carbon 38.02 per cent, ash 7.28 per cent, and the B. t. u. value 9,303. As far as could be determined by the eye or touch, this prepared coal was as dry as eastern coals which contain but 1 per cent of moisture, showing that the moisture content of the lignite coal was mainly inherent moisture.

The actual evaporation per pound of dry coal varied from 5.6 to 5.74 lb., the equivalent evaporation per pound of dry coal varying from 6.75 to 6.92 lb.

Contrary to expectations, no difficulty of any kind was encountered due to the high moisture content of the coal and it burned at all times with a clear, bright flame and practically colorless stack. The amount of slag and ash remaining in the fire pan or combustion chamber was the least which had been encountered with any kind of coal which had so far been burned on this locomotive, including bituminous, anthracite silt, etc. The amount of honeycomb which was formed on the flue sheet was practically negligible and did not interfere with the steaming of the locomotive.

Little change was made in the equipment on the locomotive to burn the lignite from what was previously used to burn the mixture of anthracite silt and bituminous. The tips in the exhaust pipes were bored out 3¾ in. diameter each, whereas they had previously been 3½ in. in diameter for the hand fired locomotive and 4 in. when burning the mixture of anthracite and bituminous. The only other change was the placing of three more air openings in the bottom of the fire pan or combustion chamber.

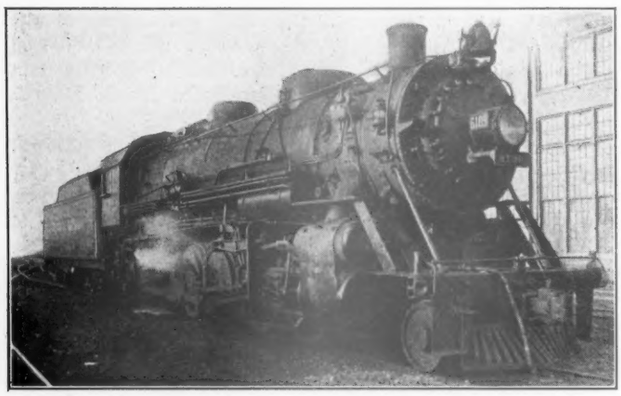
ACCORDING TO THE STATISTICS of the American Iron & Steel Institute, the tonnage of rails produced in the United States in 1920 was 2,604,116, an increase of 400,273 tons, when compared with 1919, a decrease of 340,045 tons as compared with 1917—the best war year—and a decrease of 898,664 tons as against 1913. Of the 1920 tonnage, only 142,899 tons were made by the Bessemer process.

The Automatic Control of Locomotive Cutoff

Tests on Big Four Demonstrate Its Practicability, Utilizing Back Pressure as Actuating Force

BY E. S. PEARCE
Mechanical Engineer, Cleveland, Cincinnati, Chicago & St. Louis

LOCOMOTIVE drawbar pull is the result of steam pressure on the pistons. Variations in the amount of draw bar pull with changes in speed re the result of variations in the average pressure against the pistons, and changes in the average pressure against the pistons are the result of changes in the quantity, pressure and temperature of the steam admitted to the cylinders at the beginning of the stroke.



Mikado Locomotive Equipped for Automatic Control of Cutoff

Graphically, the relation of quantity and pressure are represented by the indicator card. As shown by Fig. 1, steam is admitted to the cylinder from the point of admission A to the point of cutoff B, at a pressure of P lb. At the point B the amount of steam in the cylinder, for all practical purposes, is the amount used in the development of the work of one stroke. From B the steam expands the remainder of the

Differential Valves Connected to Exhaust Passages and to Reverse Gear

stroke to the point of release C. On the return stroke the steam is expelled from the cylinder between C and D to the point of compression. During the time this steam is being expelled it is exerting against the piston a back pressure P_2 tending to reduce the positive force of the steam against the opposite face of the piston.

The exhaust or back pressure, P_2, varies directly with the admission pressure P_1, the length of cutoff, speed and the ability of the boiler to supply steam at the rate required to maintain P_1. It varies indirectly with the size of exhaust ports and passages.

Fig. 1 shows the value of back pressure when a constant cutoff is used through a range of increasing speeds as compared to the changes that take place in the admission pressure. The admission pressure falls off with increasing speed due principally to the inability of the boiler to supply steam in such increasing quantity and also on account of the decreased time interval for admission. Back pressure increases with increased speed due almost entirely to the shortened time interval for the escape of the steam. The net effect of the change in P_1 and P_2 was to reduce the area of the indicator card, which is the measure of the average mean effective cylinder pressure.

From the indications of the card, it is reasonable to suppose that somewhere between 12 and 26 miles an hour a shortening of the cutoff would have produced a card of greater area, regardless of the fact that a lesser number of cubic feet of steam would have been admitted to the cylinders. This increased area would be due to the higher value of P_1 caused by the smaller demand on the boiler and there being

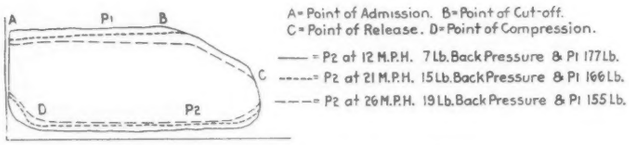

A
P1
B
C
D
P2
A= Point of Admission. B= Point of Cut-off.
C= Point of Release. D= Point of Compression.
—— = P2 at 12 M.P.H. 7 Lb. Back Pressure & P1 177 Lb.
----- = P2 at 21 M.P.H. 15 Lb. Back Pressure & P1 166 Lb.
– – – = P2 at 26 M.P.H. 19 Lb. Back Pressure & P1 155 Lb.

Fig. 1—Indicator Card Showing Relation Between Exhaust and Admission Pressure and Area with Fixed Cutoffs as Speed Increases

less steam in the cylinder to be exhausted the value of P_2 would be less. Should this supposition prove correct the decrease in drawbar pull would be less rapid and the amount of work per pound of steam used would be greater. Within the reasonable limits of practical application it is also possible that the exhaust pressure may bear a relation of a more or less constant nature to P_1, the point of cutoff and the speed, such that by adjusting the cutoff to hold the exhaust pressure at a constant value an indicator card of the maximum area will be obtained for each speed within the limits of the boiler capacity.

The theory so far advanced, if of any practical value, should easily be demonstrated by the analysis of actual road tests conducted for that purpose. Such tests have been conducted on the Big Four in which no refinements of observation or calculations were indulged in not within the reasonable limits of every day performance. The conclusions, therefore, are within the reasonable limits of practical application.

It is first necessary to determine just what relation cutoff bears to drawbar pull, then what relation mean effective cylinder pressure bears to cutoff, through the same range of speeds. These relations being established, the variation of exhaust pressure as related to speed, cutoff, or mean effective

cylinder pressure can easily be determined. Since the exhaust creates draft and draft supports combustion, which must go on at a certain rate to supply steam, the relation of exhaust pressure and draft must also be determined. Part of the heat of combustion is used in superheating the steam. Since the steam supply, as controlled by cutoff, bears a possible relation to exhaust pressure and since draft may also bear such a relation, it is essential that the relation of superheat to back pressure be determined throughout the working range of cutoffs.

For determination of the above relations and variations in each specific element, a stoker fired locomotive of the Mikado type with the following dimensions was used:

Cylinders	27 in. by 30 in.
Tractive effort	50,000 lb.
Diameter of drivers	63 in.
Steam pressure	200 lb.
Grate area	60 sq. ft.
Evaporative surface	4,650 sq. ft.
Superheat surface	1,163 sq. ft.
Weight on drivers	246,000 lb.
Valve gear, Walschaert.	

With respect to the relation of the position of the reverse lever to the amount of steam travel of the piston for several positions of the reverse lever, it should be noted that from the corner back to the third notch the cutoff was shortened .705 in., from the third to the sixth notch 2.135 in., and from the sixth to the ninth, the shortest cutoff, 5.74 in. The effect of one notch adjustment near the corner is, therefore, about one-eighth that of one notch near the center.

The range of speed through which one cutoff will maintain a greater drawbar pull than the next longer or shorter cutoff is very clearly shown in Fig. 2 by the relation of the drawbar pull-speed curves for the positions of cutoff with the reverse lever in the first, third, sixth and ninth notches. The extent to which the use of one cutoff through a considerable range of increasing speeds will tax boiler capacity is shown by the

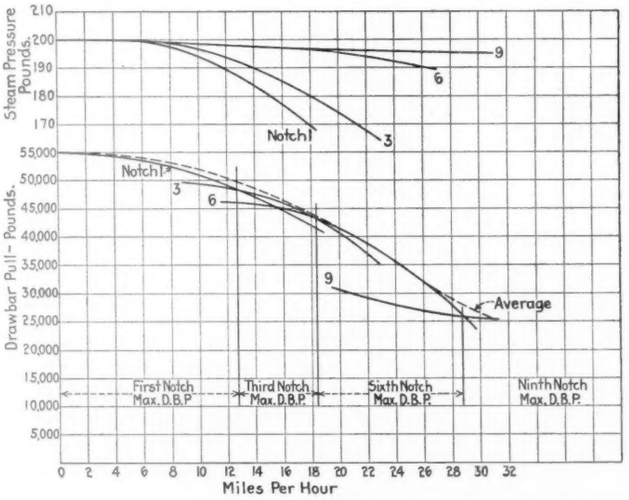


Fig. 2—Variation of Drawbar Pull and Boiler Pressure as Speed Increases with Four Positions of Cutoff

rate at which boiler pressure falls off as speed increases. It is evident that using the incorrect cutoff when maximum capacity is required will not only prevent such capacity being developed, but will needlessly tax the steaming capacity of the boiler. Cutoff changes to develop maximum drawbar pull at each speed on this particular class of engine should be made as follows:

First notch, 89.1 per cent C. O.....0 up to 12-14 m.p.h.
Third notch, 86.75 per cent C. O....12-14 m.p.h. to 18-19 m.p.h.
Sixth notch, 79.65 per cent C. O....18-19 m.p.h. to 28-30 m.p.h.
Ninth notch, 60.5 per cent C. O.....28-30 m.p.h. up.

In actual practice with either increasing or decreasing speed this number of cutoff changes would not be made, although the advantage of so doing must be evident. In fact, the notches between those cited could be used with profit.

Mean effective cylinder pressure, back pressure and their relation to speed are shown in Fig. 3. Since mean effective cylinder pressure produces drawbar pull, the cutoff changes required to hold it at the maximum with changing speed should correspond to those required to hold drawbar pull at the maximum. From Fig. 3 these are found to be as follows:

First notch.....Up to 12-14 m.p.h.
Third notch.....12-14 m.p.h. to 15-16 m.p.h.
Sixth notch.....15-16 m.p.h. to 28-30 m.p.h.
Ninth notch.....28-30 m.p.h. and up.

The slight discrepancy in speed at the upper limit of the third notch and the lower limit of the sixth notch does not

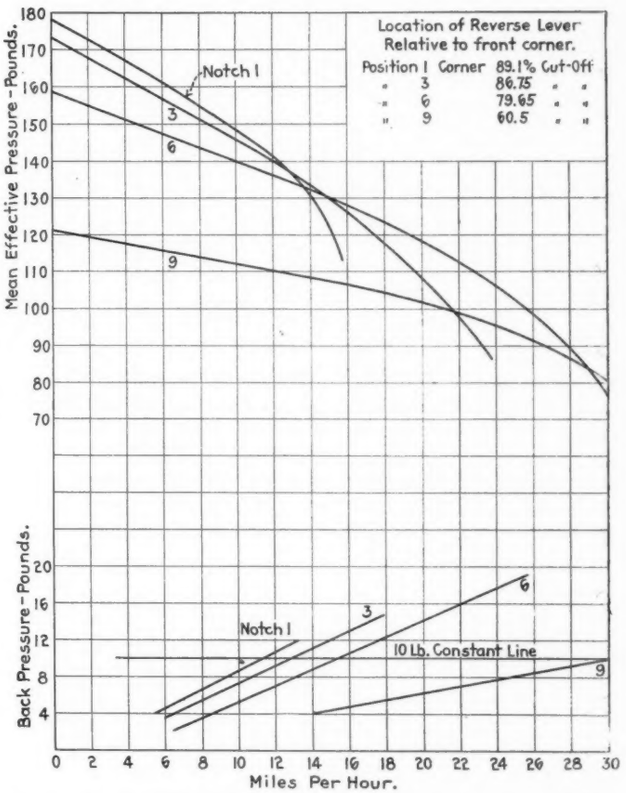


Fig. 3—Relation Between Average Mean Effective Pressure, Back Pressure and Speed for Four Positions of Cutoff

detract from the theory and the fact that mean effective pressure falls off at a more rapid rate than boiler pressure, as shown in Fig. 2, while back pressure increases in practically direct proportion to increasing speed, is a practical demonstration of the theory set forth in connection with Fig. 1. Attention is called to the fact that the back pressure curve for each cutoff shows a value of approximately 10 lb. at the same speed at which the cutoff should be changed to hold mean effective pressure as well as drawbar pull at a maximum.

Since back pressure apparently bears some constant relation to mean effective cylinder pressure and thence, through cutoff, to drawbar pull, there must be some point of maximum return to be expressed in pounds mean effective cylinder pressure per pound of back pressure. Fig. 4 shows the ratio of mean effective pressure to pounds of back pressure for the various cutoffs and back pressures. The longest cutoff gives the maximum return in pounds mean effective pressure per pound of back pressure up to a point between 10 and 12 lb. back pressure, which occurs for this cutoff at 12 to 14 miles an hour. All values of cutoff show that with 10 to 12 lb

back pressure the pounds mean effective pressure per pound of back pressure are approximately the same. Therefore, if each cutoff is changed when a speed is reached such that back pressure has reached between 10 and 12 lb., the maximum

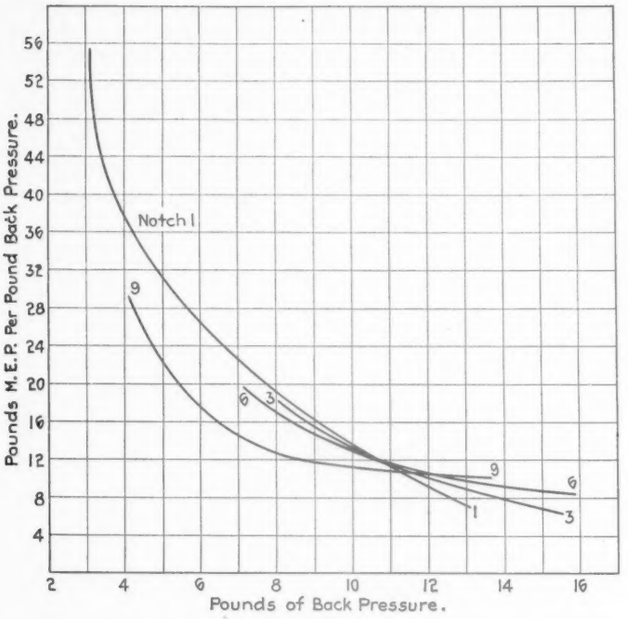


Fig. 4—Average Pounds Mean Effective Pressure Per Pound Back Pressure for Four Positions of Cutoff

return for the back pressure carried will be obtained, both in economy as to mean effective pressure and capacity as to the drawbar pull obtained as a result of the change. That

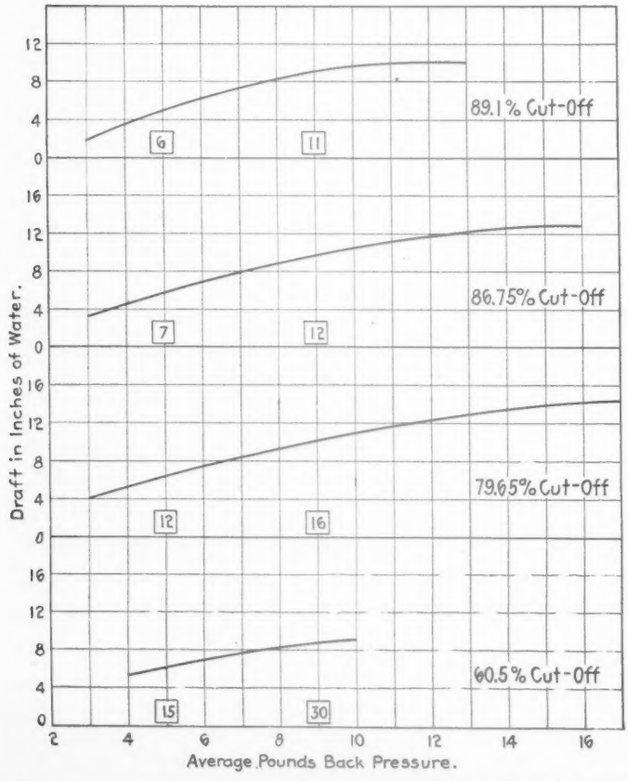


Fig. 5—Back Pressure and Average Draft at Base of Stack for Four Positions of Cutoff with Varying Speed

10 to 12 lb. back pressure is the point of maximum return is still further evidenced by the fact that the relative positions of the several curves in Fig. 4 are reversed on either side of this critical range.

The relation of draft to back pressure is shown in Fig. 5. Dr. Goss in his book on "Locomotive Performance," states that:

"First—Changes in cutoff have no effect upon the form and character of the jet, except insofar as they affect the quantity of steam discharged.

"Second—With a given weight of steam discharged, whether in heavy exhausts incident to low speed, or the more rapid impulses at high speed, the draft resulting is practically the same. But whenever the weight of steam discharged per minute changes, the draft will change.

"Third—In any boiler the condition of draft determines the rate of combustion and consequently under ideal conditions, the draft will be a function of the rate of combustion."

From Fig. 5 it will be seen that for all of the cutoffs shown, constant back pressure is synonymous with constant draft. This seems to be contradictory to the first and second con-

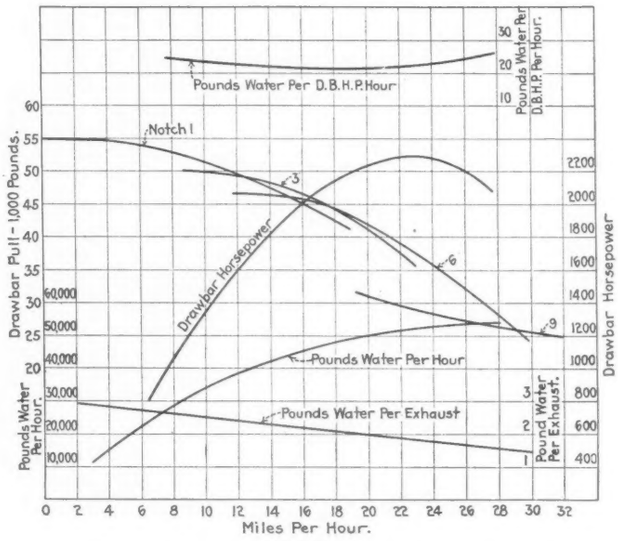


Fig. 6—Drawbar Pull, Horsepower and Water Rate; Cutoff Adjusted for Varying Speed, as Shown in Fig. 2

clusions of Dr. Goss since as speed increases and cutoff is shortened, the quantity of steam exhausted per minute increases with speed as shown by Figs. 6 and 7. It should be noted that as cutoff is shortened with increased speed the amount of steam discharged per exhaust decreases from 2 miles an hour to 28 miles an hour by 45.8 per cent, whereas the quantity per minute increases over the same range by 1,460 per cent. At low speeds the intervals between exhausts is large and the quantity of steam discharged per exhaust is also large. At high speeds the intervals between exhausts is small and the quantity of steam discharged per exhaust is also small. Low frequency and high quantity in one case is equalled by high frequency and small quantity in the other; the result is a constant.

Constant draft through a range of speed requiring an increasing rate of steam supply and consequently an increasing rate of combustion if steam pressure is to be maintained within working limits, may seem to be contradictory to the third deduction made from the experiments of Dr. Goss. Analysis of the conditions of actual operation very easily explains the consistency of both statements. To supply steam at low rates a heavy fire is used, giving greater resistance to the passage of a given quantity of air through the fuel bed

in a given time, hence a high draft is required although less air is required in a given time than at high speed. To supply steam at high rates a light fire is used with lower resistance to the passage of the air, yet the quantity of air required in a given time is greater than at low speed. For all practical purposes draft is constant for varying rates of combustion and the air supply automatically controlled by the thickness of the fuel bed.

The statement that conditions of operation actually require constant draft is further substantiated by the relation of superheat to back pressure. Shortening the cutoff to hold back pressure constant as speed increases results in constant draft and as a result of this regulation of the quantity of steam passing through the superheater, practically a constant amount of superheat is obtained throughout a great range of speed. For back pressures from 8 to 13 lb. the superheat is the same. The higher back pressure is the maximum of economical return in draft and the range is within that obtained with low as well as high speed.

In summing up the analysis of back pressure and the relation of back pressure to the several features of locomotive operation it would seem that operating an engine to constant back pressure should regulate the cutoff to sustain the maximum drawbar pull at all speeds and consequently develop the maximum drawbar horse power at each speed; and that in developing the maximum drawbar horse power at each speed the required number of pounds of water per drawbar horse power would be supplied, the draft and superheat being so regulated that the boiler would maintain adequate working pressure.

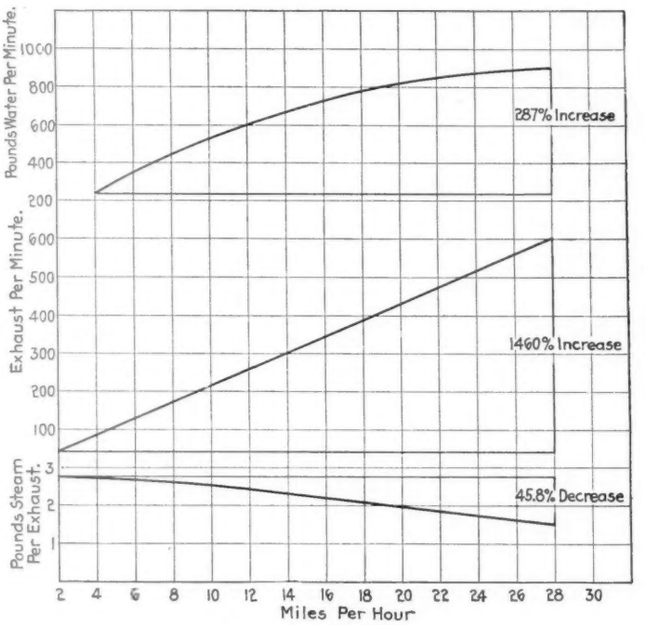


Fig. 7—Total Rate of Steam Discharge Per Minute. Cutoff Changed at Speeds as Shown on Fig. 2

With the pressure, volume, and temperature of the steam used in a given time known, it is possible to calculate the weight of steam used within practical limits of accuracy, which is sufficient for comparing the steam consumption per unit of work at one speed with that at another. From the indicator card the volume of the steam and the average pressure at the point of cutoff can be obtained. The temperature of the steam may be that shown by the pyrometer, which will give the degrees superheat over the saturated temperature at the cutoff pressure, or the total superheat over the saturated temperature at cutoff may be assumed as that of the saturated temperature at boiler pressure plus the degrees superheat indicated by the pyrometer. In either case the error is negligible. From the data shown on Fig. 6 and previous charts, such calculations may be made.

Applying this method of calculation, the amount of steam per minute, per exhaust and per drawbar horsepower-hour shown in Table I and in Figs. 6 and 7 have been obtained. The water or steam per drawbar horsepower hour is well within the limits of economical performance and at the maximum is within the limit of economical combustion.

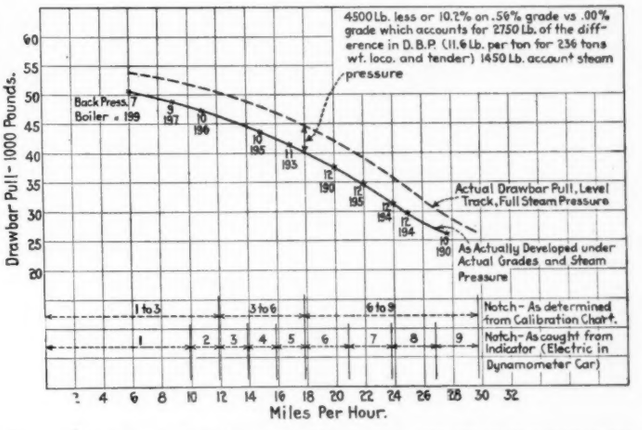

4500 Lb. less or 10.2% on .56% grade vs .00% grade which accounts for 2750 Lb. of the difference in D.B.P. (11.6 Lb. per ton for 236 tons wt. loco. and tender) 1450 Lb. account steam pressure
Drawbar Pull - 1000 Pounds.
Back Press. Boiler = 199
Actual Drawbar Pull, Level Track, Full Steam Pressure
As Actually Developed under Actual Grades and Steam Pressure
1 to 3
3 to 6
6 to 9
Notch - As determined from Calibration Chart.
Notch - As caught from Indicator (Electric in Dynamometer Car)
Miles Per Hour.

Fig. 8—Maximum Drawbar Pull Compared with That Developed by Regulating Cutoff to Maintain Constant Back Pressure

The ability of the engine to maintain steam pressure when operated at 10 to 12 lb. back pressure and the extent to which the maximum drawbar pull will be developed at each speed is shown in Fig. 8. In the operation of the reverse lever to hold the back pressure constant, accelerating a maximum tonnage train from 3 to 28 miles an hour on grades of —.13

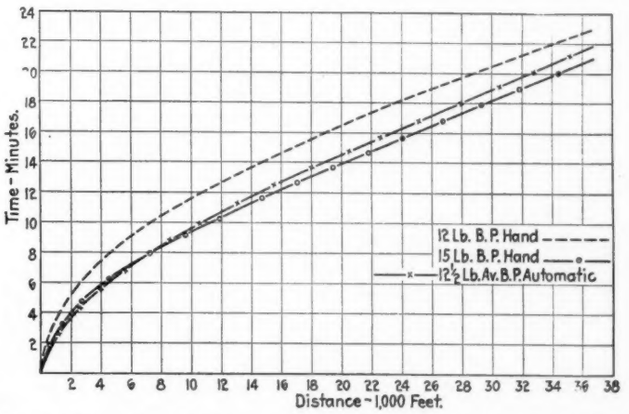


Fig. 9—Time Distance Curves for Runs Under Varying Conditions of Back Pressure

per cent to +.629 per cent, the cutoff was changed 14 times in 7 min. 23 sec. and in a distance of 2.4 miles.

The practical application of the back pressure method of cutoff control so far as the manual operation of the reverse lever is concerned, presents a serious problem because too much of the engineman's time would be required to properly manipulate the reverse lever. To overcome the disadvantage of manual operation of the reverse lever the back pressure principle has been applied to a system of valves which, actuated by back pressure and synchronized with the throttle, automatically operates a power reverse gear to adjust the cutoff and thereby relieve the engineman.

Automatic operation of the reverse lever possesses mechanical, economical and capacity increasing advantages, and it is also on the side of safety. Mechanically the advantages are independence of valve setting, reach rod length or fineness of the quadrant notches, and the elimination of mechanical appliances for the indication of speed, making the adjustment independent of conditions of wear, which would tend toward the inaccuracy of a mechanical speed actuated device. Economical advantages are the operation of the unit to the maximum economical capacity as to hauling light trains or heavy trains at the speeds consistent with the loading, and uniform and synchronous operation with respect to steam

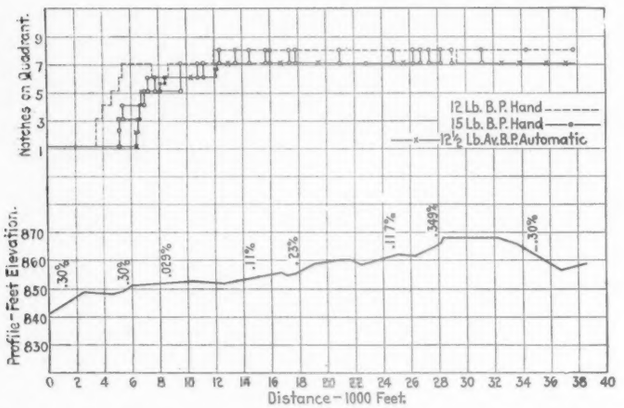


Fig. 10—Profile and Reverse Lever Positions for Runs Shown in Fig. 9

generation and consumption, draft, cutoff, superheat, and drawbar pull. From the standpoint of safety, the advantages are—relief for the engineman from a time absorbing duty, permitting concentration upon such other operating duties as the water, sand, throttle and signals.

The automatic device for the adjustment of cutoff consists essentially of three parts. Two differential valves set

Table I—Comparison of Steam Consumption in Lb. per Minute as Calculated from Indicator Card by

(1)—Pressure and Temperature at Cutoff, Plus 250 Deg. Superheat, and

(2)—Pressure at Cutoff and Temperature at Boiler Pressure, Plus 250 Deg. Superheat

Miles per hour	Revolutions per minute	Volume of four cylinders per revolution at % cutoff	Cubic feet steam per minute	Cu. ft. steam per pound at cutoff pressure plus 250° superheat	Pounds steam per minute	Pounds steam per exhaust	Cu. ft. steam per lb. at cutoff pressure and temperature at boiler pr., plus 250° s.h.	Pounds steam per minute	Pounds steam per exhaust	Exhausts per minute
2	10.7	35.4	379	3.2	118.5	2.75	3.2	118	2.75	42.8
4	21.4	35.4	757	3.28	231	2.7	3.28	231	2.7	85.6
6	32.0	35.4	1130	3.34	338	2.66	3.4	332	2.59	128.0
8	42.7	35.4	1510	3.5	430	2.53	3.46	436	2.86	170.8
10	53.5	35.4	1890	3.6	525	2.45	3.6	525	2.45	214.0
12	64.0	35.4	2260	3.7	610	2.38	3.8	595	2.32	256.0
14	74.8	34.5	2580	3.89	663	2.21	4.0	645	2.16	299.0
16	85.5	34.5	2950	4.05	728	2.13	4.1	720	2.1	342.0
18	96.2	34.5	3320	4.2	790	2.06	4.3	772	2.01	384.0
20	107.0	31.6	3380	4.4	767	1.79	4.5	780	1.75	428.0
22	117.5	31.6	3710	4.6	807	1.72	4.7	790	1.68	470.0
24	128.5	31.6	4070	4.8	849	1.65	4.9	830	1.615	514.0
26	138.0	31.6	4360	5.0	872	1.58	5.2	840	1.53	552.0
28	156.0	31.6	4920	5.5	895	1.49	5.7	865	1.44	600.0

Note—Cutoffs and speeds as shown in Fig. 2.

one pound apart are provided, one for shortening the cutoff when the back pressure increases, and the other for lengthening the cutoff when the back pressure decreases. Both valves are connected to the four exhaust passages of the cylinder saddles and to the air supply for the power reverse gear. A circular quadrant and cutout valve are so arranged that a finer cutoff than the engine will practically operate under at high speeds cannot be obtained. The circular quadrant permits the reverse lever to follow the gear and indicates the cutoff and also serves as a quadrant for the reverse lever when under hand control. A control valve is connected to the throttle so that the engine is placed in automatic cutoff and the reverse lever cannot be manipulated by hand when a full throttle is used. At any predetermined speed the throttle may be manipulated to restore hand control and with a small throttle opening, such as used in the movement of the engine alone or the engine and a few cars, the reverse lever may be manually operated.

Three comparative tests to determine the advantages of automatic operation were conducted under constant conditions of train loading, grade and direction. In the first test, the reverse lever was operated by hand to hold 12 lb. back pressure and the time to cover a given distance, while accelerating the train from a stand, was recorded. The second test was the same except that 15 lb. back pressure was to be maintained. The conditions of the third test were the same except that the reverse lever was automatically operated to maintain 12½ lb. back pressure. All tests started from the same point and a full throttle was required. The train consisted of 55 loaded cars of 3,479 tons actual weight.

Fig. 9 is the time-distance chart of these runs, which shows that six miles was covered in 20.9 min. in the first

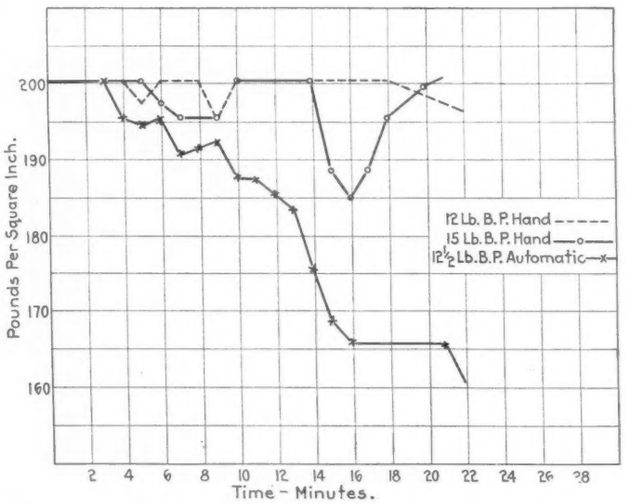


Fig. 11—Steam Pressure on the Three Runs Shown in Figs. 9 and 10

test, in 18.5 min. in the second test and in 19.3 min. in the third test.

Fig. 10 shows the rate at which the cutoff was changed and the nature of the grades negotiated. In the first 10,000 ft. seven adjustments were made in 11.4 min., or one every 1.6 min., in the first test; six adjustments were made in 9.0 min., or one every 1.5 min., in the second test, and in the third test six adjustments were made in 9.4 min., or one every 1.56 min.

Some time had elapsed between the first and third tests and as a result, the condition of the fire in the test of the automatic device was not as conducive to good steam pressure as in the two previous tests. Since this condition, however, is to be expected no steps were taken to better it. Fig. 11 shows the steam pressure conditions under which the three tests were run and explains why the automatic device held the engine in the corner longer than was required in the first two tests and did not hook back to the same short cutoff that was obtained in the other tests. It is remarkable, how-

ever, that in spite of the lower steam pressure the performance practically equalled the first two tests.

The modern locomotive with all the capacity and economy producing specialties and features of design may be divided into two parts by a line extending horizontally under the fire box and through the valve, from tender end sill to pilot beam. Above this line there is every development to produce steam economically and in quantity. Below this line there is every development to utilize the steam and the potential capacity of the entire machine in the production of drawbar pull and gross ton miles—the ultimate justification for the investment The extent to which the ultimate return in capacity and economy is realized depends upon the element of personal skill of the engineer.

The function of cutoff adjustment is the accurate and constant transfer of energy and the extent to which accuracy and constancy are obtained is the measure by which net return is realized.

American Society for Testing Materials

Annual Meeting Discusses Specifications for Cast-Iron Car Wheels; Also Sulphur and Phosphorus in Steel

AT THE twenty-fourth annual meeting of the American Society for Testing Materials held at Asbury Park, N. J., June 20 to 24 inclusive, a number of papers and committee reports were presented and discussed. Several of the subjects considered and the actions taken are of particular interest to railroad men.

Chilled Cast-Iron Car Wheels

A large part of the evening session of June 24 was taken up with the report of Committee A-3 dealing mainly with specifications for chilled cast-iron car wheels presented by Dr. Richard Moldenke, a paper entitled "Some Failures of Cast-Iron Wheels," by H. J. Force, and a lively discussion which was entered into by many railroad men and representatives of cast-iron car wheel manufacturers who were present.

The paper by Mr. Force was an excellent presentation of the importance of including chemical requirements in the specifications for cast-iron car wheels. An abstract of this paper is printed elsewhere in this issue. The question of including chemical specifications has provoked considerable discussion in the past but up to the present time they have not been included, owing largely to the difficulty of determining the limits of certain elements.

Those who took part in the discussion as representatives of the car wheel makers included George W. Lyndon, president of the Association of Manufacturers of Chilled Car Wheels, which includes 25 companies having a capacity of 25,000 car wheels per day; F. K. Vial, consulting engineer of the association and of the Griffin Car Wheel Company; H. E. McClumpha, National Car Wheel Company; Mr. Courtney, New York Car Wheel Company, and H. C. Brown, Brown Car Wheel Company. All of the manufacturers' representatives who participated in the discussion, recognized the importance of chemical specifications and favored the inclusion of limits, usually very nearly the same as those suggested by Mr. Force. Several stated that they were now manufacturing wheels to similar specifications of their own. Mr. Vial said that in his judgment the amount of combined carbon and the depth of the chill should be included in any specification and that it was vital that there be a proper balance between the elements with combined carbon not over 0.85 to 0.90 per cent and with manganese at least three times the sulphur content. The only serious question raised was how southern and Pacific coast manufacturers would be able to keep phosphorus between 0.30 and 0.40 per cent when their pig iron already ran to 0.50 per cent.

Robert Job, vice-president Milton Hersey Company, Ltd., Montreal, Canada, and formerly with the Lehigh Valley, stated that the proposed specifications were similar to those which had been used on the Lehigh Valley with excellent satisfaction. Repeated analyses which he had made of car wheels which had failed in service showed that combined carbon had exceeded 0.90 per cent and that the phosphorus was over 0.30 per cent and sulphur over 0.15 per cent. C. T. Ripley, general mechanical inspector, Atchison, Topeka & Santa Fe, favored the proposed specifications and also strongly advocated the arch plate pattern wheel, which he said has materially reduced the occurrence of slag inclusions and has minimized the danger of cracked plates. G. E. Doke, engineer of materials, New York Central, Cleveland, O., advocated the suggested chemical specification which he believed would result in better wheels. He also emphasized the need of a thermal test, citing instances of wheels containing 1.02 per cent combined carbon which failed in 150 sec. and wheels of 1.26 per cent combined carbon which failed in 100 sec. in such a test.

Referring to the recommendations of Mr. Force relative to the presence of nickel and chromium, Doctor Moldenke advocated their inclusion in the original pig and not by means of alloys or otherwise. He also emphasized the necessity of closely watching cupola practice and claimed that by the use of the basic electric furnace in conjunction with the cupola, the desired results as to refinement and composition could be obtained by direct action.

By a vote of the society the report of the committee was adopted, including the following chemical requirements:

	Per cent
Combined carbon	0.50 to 0.85
Manganese	0.50 to 0.75
Sulphur	0.18 maximum
Phosphorus	0.30 to 0.40
Silicon	0.45 to 0.75

The tentative specifications for chilled cast-iron wheels embody the well-known A.R.A. requirements with the addition of the above chemical limitations, which is a most important step forward.

Steel Specifications

The report of the Committee on Steel was presented by its chairman, F. W. Waring, engineer of tests, Pennsylvania System, Altoona, Pa. The most important subject taken up was that relative to the allowable limits for phosphorus and sulphur. During the war the limits on these elements in 43 specifications were increased 0.01 per cent on account of the difficulty in obtaining a sufficient amount of suitable melting stock and low sulphur fuels and a note to that effect was added to the various specifications for steel. In 1919 the tolerance was removed from all but 14 of the specifications, on which it was allowed to remain a while longer. The committee recommended that the note relative to allowances now be removed from the remaining specifications and that for three classes of structural steel—namely, those for locomotives, cars and ships—the limit for sulphur be raised from 0.05 to 0.06 per cent due to the heavy tonnage involved and

to the continued difficulty in obtaining low sulphur fuels and melting stock. The sulphur tolerance is thus removed from specifications for materials usually worked hot and retained for structural materials generally fabricated cold. For steel castings where the same difficulties still exist, it was recommended that the limit for sulphur be raised 0.01 per cent. The phosphorus requirement for acid steel was also raised 0.01 per cent.

All the recommendations of the committee were adopted. Bessemer steel specifications for rails, splice bars, reinforcement bars, tie plates and track bolts now require conformity to the original specifications for phosphorus. The original sulphur limits are also restored for rivet steel, boiler tubes, seamless tubes and steel chain.

The committee reported that a comprehensive survey of the effects of phosphorus and sulphur in steel castings was well under way in the hands of a large joint committee under the chairmanship of the Bureau of Standards. When this work is completed it is anticipated that important and intelligent action can be taken on the subject of specifications for steel castings.

It was recommended that specifications for the heat treatment of steel forgings and billets be revised. At present the specifications state that forgings should be allowed to become cold after being forged, but it was recommended that they be changed to call for cooling only to a temperature below the critical range.

Other matters which the committee is taking up are specifications for steel sheets, methods of conducting tests and welding requirements, on the last of which it is working in conjunction with the American Bureau of Welding.

Other Papers and Reports

Interesting papers were presented on impact tests of steel castings, strength of steel at high temperatures and magnetic testing of springs by which means it was thought that many defects could be located.

The Committee on Cast Iron in addition to its report on chilled cast-iron car wheels took up the subject of so-called "semi-steel" castings. This is a loose and more or less misleading name given to a very useful form of cast iron. The addition of steel scrap to foundry mixtures dates back to the Civil War and through the reduction of the total carbon, the strength of the castings is thereby greatly enhanced. Specifications for metal of this character are under consideration and it was thought advisable that some other and more distinctive name such as "high test" cast iron be adopted.

Other subjects covered by committee reports included rules for heat treatment, corrosion of iron and steel, specifications for coke, metallography, non-ferrous metals, concrete and reinforced concrete and specifications for steel and wrought iron pipes, tubes and staybolt iron.

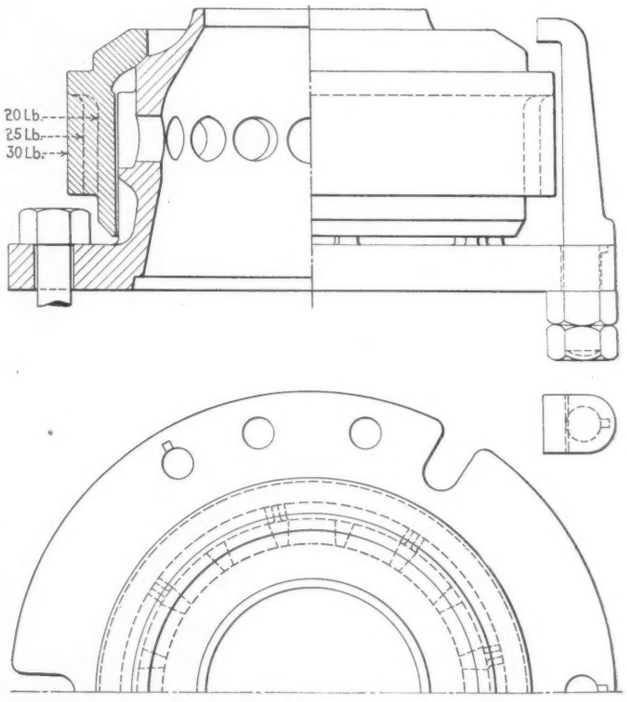
An Austrian Suburban Locomotive

Automatic Variable Exhaust Nozzle

BY CLARENCE ROBERTS

The variable exhaust nozzle has long been looked upon with favor by motive power officers of foreign railways because by its use back pressure in the cylinders can be minimized with a resultant increase in the efficiency of the locomotive.

The orifice opening of nearly all variable exhaust nozzles is adjusted by hand regulation under the control of the engineman and with this type, when engine crews receive a bonus for fuel saving, good results are obtained. The Great Western Railway system of England uses an exhaust nozzle known as the automatic jumper blast pipe top and ring in which the varying of the area of the nozzle orifice is automatic, this nozzle having been introduced by G. J. Church-

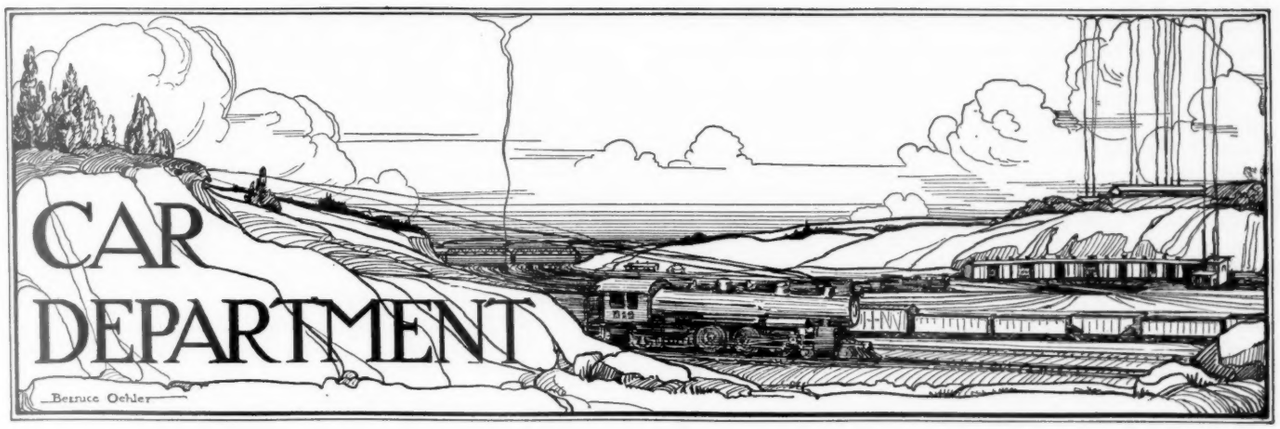


Automatic Jumper Blast Pipe Top and Ring

ward, chief locomotive superintendent. An idea of its operation may be obtained from the accompanying illustration.

The device consists of two parts, the nozzle proper and the jumper, or ring surrounding it, there being a chamber between the two. Exhaust steam in addition to passing out of the main nozzle orifice flows laterally through the holes in the wall of the nozzle into the chamber and has a tendency to raise the jumper. When the pressure in the chamber becomes sufficient to overcome the weight of the jumper, it is raised from its seat and an additional orifice is provided in the form of an annular opening surrounding the nozzle. The increase in orifice area of a nozzle of from 4½ in. to 5⅝ in. diameter is 12½ sq. in. The jumper can be designed to raise at any desired exhaust steam pressure by increasing or decreasing its weight.

With proper design the jumper raises, increasing the exhaust steam orifice when the locomotive is starting or when running with long cut-off on heavy grades, etc., the inner nozzle producing sufficient draft to meet average running conditions. Sudden and severe loads do not proportionately increase the back pressure in the cylinders nor tear the fire. For these reasons the use of the device has resulted in fuel economy and increased efficiency of the locomotive.



Factors To Be Considered in Freight Car Designing

Arranging Details to Reduce Cost of Construction and Maintenance; Avoiding Troublesome Defects

BY ALBERT H. LAKE, JR.

TO DESIGN an efficient and economical freight car it must be considered from three different points of view: namely, the purchaser's, the builder's and the operator's. To disregard any of these will result in a poorly designed or expensive car.

There is not and never will be such a thing as a standard car, and the details that will absolutely interchange between all different types of cars are very few. This was conclusively proved by the experiment of the U. S. R. A. in 1918. Such details as hand brake wheel, ratchet wheel, ratchet wheel pawl, rear draft lugs, cylinder push rod, defect and routing card boards and hand brake chain on the body and the brake beam end hangers and dead lever guides on the trucks can usually be made to interchange on all types of cars.

Such details as striking plates, front draft lugs, push pole pockets, body bolster center braces, center plates, side bearings, ladder rounds and uncoupling device can be made to interchange on a few types of cars. However, it is not a good policy to materially sacrifice the design of a car to accommodate details. In addition to these there are the A. R. A. standards that will interchange on all cars of the same capacity. It is nearly impossible and very impractical to design a car and not use patented specialties.

Under Frame and Superstructure

In preparing the design the under-frame is usually considered first. It should be of sufficient strength to carry the rated capacity plus 10 per cent overload, uniformly distributed. For some types of cars, such as flat and drop end gondola, the underframe is also calculated for 75 per cent of the rated capacity distributed over a distance of 10 ft. at the center. This is done to take care of shipments of heavy machinery that may be loaded at the center of the car and for long structural steel girders supported at the center of two adjacent cars.

The area of the center sills and the ratio of stress to end load must meet the A. R. A. requirements. For steel frame box cars where the side frames can be made to carry the load, rolled channels should be used for center sills. Fish-belly sills are sometimes used, but they add unnecessary weight, and while they were used extensively in the past have now become practically obsolete. Fish-belly sills, built up of plates and angles, give good satisfaction and are more economical as the flange angles can be made heavy and the web plate light, giving a better distribution of metal than can be obtained in the pressed sill.

Rolled Z-bars are the most economical and are usually used for the side frames of single-sheathed box cars, although pressed steel members have given good results. A better connection at the side sill and side plate can be obtained when pressed posts and braces are used, although there is an objection to this construction due to the fact that it is difficult for any railroad other than the owner to make repairs.

The ends of box and gondola cars should receive special consideration. Corrugated ends for box cars have given satisfaction, but care must be exercised to connect them properly at the sides and bottom. If wood construction is used the posts at the center must be designed with a high section modulus at a point about 30 in. above the floor, as this is where the maximum bending movement will occur. Pressed steel end posts have been used with good results. For solid end gondola cars, the ends are usually made of the same material as the sides, although corrugated steel ends have been used on a large number of cars of composite construction and have given satisfaction. In any case, they must be rigidly reinforced and securely fastened at the corners. For drop ends, a number of types of construction may be used. However, the corrugated steel drop end is the most extensively employed type. Hinges and locking devices should be carefully designed and the doors rigidly reinforced.

Large end doors on automobile cars has been practically discontinued in favor of wide side doors. Such side doors are usually made in two sections and so arranged that for ordinary shipments only one section need be opened, while for loading automobiles both sections are opened. The main reason for discontinuing end doors is that it is next to impossible to build and maintain them so that they will withstand the shocks of shifting loads when the cars are used for shipments other than automobiles.

On many gondola cars the side stakes are weak and permit the sides to bulge at the center. This can be over-

come by using pressed steel stakes with a large section modulus at the top of the side sill, and extending those at the cross-bearers down as far as possible and securely riveting them to the cross-bearers and side sill.

Cross ties near the top of hopper cars have never given satisfaction and should not be used. If bulb angles are used on the top of the sides and properly designed gussets applied at the cross-bearers and bolsters, the cross ties can be omitted and a more satisfactory car obtained.

Side doors and roofs are usually designed by specialty companies, but they should be carefully selected to suit the needs of the car under consideration. Bottom-hung doors are extensively used and give satisfaction. Side-door locks and bottom guides should be so designed and applied that burglars cannot gain admittance to the car. Door starters should be applied and spark strips and top guides or tracks so designed that the door will be weather proof.

A flexible metal roof laid over wood sheathing makes a satisfactory job. An all-steel roof is also extensively used.

Draft Gear

The draft gear seems to be about the weakest part of most cars and because of the limited space it is sometimes almost impossible to make it meet the A. R. A. recommendations. Combined striking plate and front draft lugs are sometimes used to advantage; also, a combined striking plate and carrier iron. The recommended shearing area of 15 sq. in. and bearing area of 7½ sq. in. for draft gear attachments should be maintained. Therefore, there should not be less than 13 rivets of ⅞ in. diameter in each draft lug, and the draft sill or draft lug should not be less than ⅜ in. thick. With the existing standard of 21¼ in. from the coupler horn to the front follower, it is very difficult to get 13 rivets in each front draft lug. If this distance could be increased to 24 in. or 25 in., it would materially help the condition. In some tight places the horizontal forged yoke and check plates can be used to advantage.

The composite type of construction for gondola cars has proved satisfactory and some composite hopper cars have been built recently. The advantage of this type of construction is that the sides and floors can be renewed or repaired readily. Stake pockets should be applied to gondola cars. If they are applied on the inside they should be of the collapsible or disappearing type, as the rigid type is easily damaged and will not give good service. On flat cars, stake pockets must be applied and should be spaced not less than 2 ft. 0 in., nor more than 3 ft. 6 in. apart, to meet the A. R. A. rules of interchange.

Hopper car floors should be rigidly reinforced by angles or other means to prevent them from sagging on each side of the bolster, often a weak point in hopper cars.

Hopper and general service car door operating mechanisms should be so designed that it will be impossible for the operator to be injured while opening or closing the doors. In closing the doors the operating handle or lever should always work downward.

Brake Rigging

The design of the foundation brake gear should be carefully checked. The A. R. A. recommendations should be used: that is, braking power 60 per cent of the light weight of the car; cylinder pressure 50 lb. per sq. in.; maximum fiber stress for levers, 23,000 lb. per sq. in.; maximum fiber stress for rods, 15,000 lb. per sq. in.; maximum shearing stress for pins, 10,000 lb. per sq. in.

All rods, levers and pins are to be designed for an overload of 60 per cent or a cylinder pressure of 80 lb. per sq. in. The cylinder should be so located and the levers so proportioned that there will be no side movement of the cylinder push rod. If possible, pockets in the brake pipe should be avoided. The pipe should be securely clamped to prevent end shifting. The use of patented angle cock holders is desirable, but not absolutely necessary. The retaining pipe must be securely clamped and the retaining valve properly located.

The hand brake should be so designed that the hand braking power will equal the air braking power. This can be accomplished by the addition of an extra lever, by gears, or sometimes by adding a sheave wheel. The type of car under consideration will largely determine whether the ordinary brake wheel or a ratchet lever should be used. On flat and drop-end gondola cars, a drop brake mast is often used to permit the loading of long material on two or more cars. Several designs of drop-brake masts are on the market and they should be carefully selected.

The brake should be laid out in both full release and full piston travel positions to make sure that all lever guides are of sufficient length and to determine all other clearances with the car body. Cylinder and reservoir supports and lever fulcrums should be of ample strength to carry the loads to which they are subjected.

Trucks

The type of trucks chosen is largely a matter of cost, or conforming to existing standards, but they should be selected to meet the requirements of the car. Brake beams should be carefully selected and properly hung and provided with a third point suspension to guard against the brake shoes wearing tapered. Side bearings must be properly spaced and should be preferably of the roller or frictionless type. Wood spring seats should not be used, as they will not stand up under the continued action of the springs. When wheels are turned the center plate height should be maintained by the addition of metal shims under the center plate or springs, or by the addition of new metal spring seats.

Safety appliances should always meet the I. C. C. requirements with a safe margin to take care of variations in building and small damages in service. The coupler operating mechanism lifting bar should connect directly to the coupler operating eye without the use of chains or clevises. The single lever push-down type is economical and efficient and can be operated by brakemen while riding on the sill step, which is a great advantage in switching in yards where there is no hump.

The hand brake ratchet wheel and pawl must be carefully considered. The ordinary pawl must always be arranged to be operated by the brakeman's left foot. The gravity pawl is efficient and has many operating advantages.

The design of details should be closely watched. If fish-belly center sills are used, there will be a large amount of scrap plate available for small gussets and connections. It also can be pressed into angles and used in place of the customary rolled angle connections. Therefore, on designs where there will be considerable scrap plate, as many gussets and connections as possible should be made of the same thickness as the scrap.

The number of dies required in the building of cars is an important item. There should be no hesitation in using pressed details, but the details should not be made different when it is possible to make them the same. Such details as the bolster and cross-bearer diaphragms can often be pressed on the same die; in addition the shallow diaphragms can often be made all one-hand instead of "as shown, and reverse." By looking out for such points as this it will often be possible to save the expense of making new dies.

Specialties should be selected with great care. The following three points should govern such selection: adaptability, durability and cost. Every car should be equipped with all necessary appliances, but should not be loaded down with unnecessary devices to please some specialty manufacturer.

Draft Gear Tests of the Railroad Administration

Results of Car Impact Tests, Comparative Grading of Gears and General Conclusions

A VARIETY of interesting curves may be derived from the car-movement curves, but the essential features of the functioning of the gears are shown in the following, which were reproduced for each of the three runs for each type of gear:

MASTER CURVES
Car-Movement Curves—Superimposed
DERIVED CURVES
Velocity Curves
Energy Curves
Time-Force Curves
Time-Closure Curves
Force-Closure Curves

A brief discussion of each of these curves will serve to illustrate their use in analyzing the action of the gears.

Car Movement Curves—Superimposed

Irregularities in the car-movement curves are due in a large measure to the vibration or to the relative movement of the side sills. The effect of these vibrations upon the car-movement curves, is probably the best comparative measure of the smoothness of action of the draft gears that can be obtained, for the smoother the action of the gear the more gradual and regular will be the transfer of energy from the striking car to the standing car and the less will be the vibrations of the car structure. The other data derived from these curves has already been discussed.

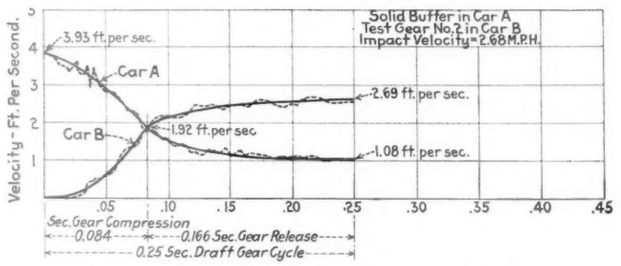


Fig. 1—Velocity Curves, Westinghouse D-3 Gears

Velocity Curves

Fig. 1 shows the derived velocity curves for the single-gear run of the Westinghouse D-3 gear at the closing speed. The irregular dotted line shows the exact first derivatives of the car-movement curves, the first derivative being instantaneous velocities. Any slight irregularity in the car-movement curve becomes very apparent in this curve. The curves for the Westinghouse D-3 gears are unusually smooth for its capacity.

The impact velocity of car A in this run was 3.93 feet per second (2.68 M.P.H.), the velocity of car B at this instant being zero. As the gears compressed, the velocity of car A decreased and the velocity of car B increased until at the instant of maximum gear compression both cars were of the same velocity, namely, 1.92 feet per second. The result of the closing of this gear, therefore, was to reduce the velocity of car A from 3.93 feet per second to 1.92 feet per second. The remainder of the change in velocity of the two cars is due to the recoil of the gear, the effect of the recoil being to increase the velocity of car B to 2.69 feet per second and to still further reduce the velocity of car A to 1.08 feet per second at parting.

The irregularities in the velocity curves are due largely to the local surging and vibrations of the side sills. With a spring draft gear, and with some of the lower capacity friction gears, the transfer of motion from one car to the other is effected with practically no disturbance of the car structure, the velocity curves being relatively smooth. On the other hand, with the higher capacity gears, considerable vibrations are set up. It is not to be expected that a gear functioning up to, say, 4 miles per hour, will give as smooth and regular a velocty curve at its closing speed as one functioning only to 2 miles per hour. The point of real interest is to compare the relative smoothness of these curves from gears of the same capacities and at approximately the same impact speed. Draft gears should be tested upon actual cars so that if a gear has a tendency to pinch and bind on compression, it will be developed and discovered.

These vibrations in the velocity curves should not be interpreted as meaning that the side sills of the cars vibrated through such distance. The actual movement of the side sills that occurred were very slight; in many instances barely more than a tremble and seldom more than ⅛ in. Mean velocity curves, shown in full lines, have been established from the general trend of the original car-movement curves, and these represent, as closely as it is practical to obtain, the true mean velocity of the entire mass of the car. This mean velocity curve is used throughout the remainder of the cards for the determination of energy and force.

Energy Curves

The energy curves shown in Fig. 2 have been produced by simple calculation from the preceding velocity curves. These energy values include not only the kinetic energy represented by the direct movement of the car as a whole, but also the energy of rotation of the wheels and axles.

In this particular run (Westinghouse D-3 single gear at closing speed) the kinetic energy of car A was reduced from 35,308 ft. lb. to 8,427 ft. lb. by the compression of the gear, while at the same time the kinetic energy of car B was increased from zero to 8,427 ft. lb. The sum of the kinetic energies of the cars at this instant, (the instant of maximum draft gear compression) amounted to 16,854 ft. lb., so that

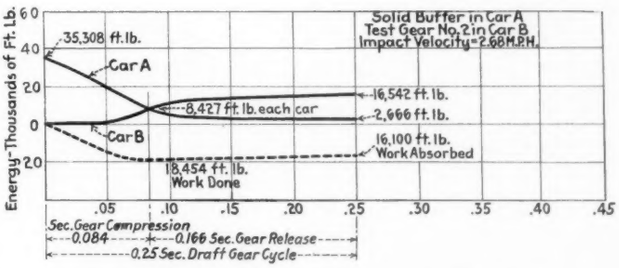


Fig. 2—Energy Curves, Westinghouse D-3 Gears

the work done in compressing the draft gear and the car structure, and in overcoming rolling and grade resistance, amounted to 18,454 ft. lb. This quantity corresponds with the expression "work done" as applied to drop testing of draft gears. The dotted line beneath the line of zero energy represents the instantaneous value of work done at any instant during draft gear compression up to the instant of maximum draft gear closure.

The energy curves during the period of draft gear release show the changes in kinetic energy produced in the cars by

the recoil of the draft gear. In this particular run the recoil increased the kinetic energy of car A to 16,542 ft. lb. and reduced that of car B to 2,666 ft. lb., so that at the instant of parting the kinetic energy represented by the movement of the two cars amounted to 19,208 ft. lb. The original kinetic energy of car A being 35,308 ft. lb., there was thus a total sbsorption in this run of 16,100 ft. lb., this quantity corresponding with the expression "work absorbed" as applied to drop testing of gears.

The maximum possible absorption of this run was 18,454 ft. lb., the work done in closing the gear; and as the absorption amounted to 16,100 ft. lb., the percentage of gear absorption in this run was 87.2 per cent.

Time-Force Curves

Fig. 3 shows the mean forces which develop between the two cars due to draft gear compression and release. The

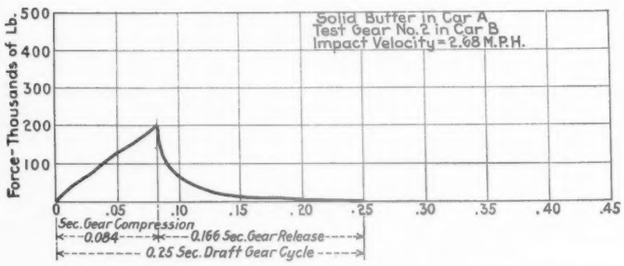


Fig. 3—Time-Force Curves, Westinghouse D-3 Gears

force is plotted against time, and the curve thus shows the building up of the force throughout the period of compression, to a peak at the point of maximum gear closure. During the release period the force falls off suddenly in the case of a friction gear.

The portion of the time-force curve to the left of the peak denotes mean draft gear compression forces while that to the right denotes the forces of release. The force has been obtained by calculating the forces required to produce the recorded changes of velocity over a given period of time. It is unquestionable that in many of the gears, probably in every case, the sticking and irregularity of gear closure was accompanied by high forces which, because of their very limited duration, could not manifest themselves in the time-displacement curves. The mean or average forces and the ultimate peak forces as deduced in these curves, however, are substantially correct and it is questionable whether after all the mean force as depicted, or in other words the force supplied over long enough period of time to produce penetration or to do the work of rupture, is not the real damaging factor.

The time-force curves will assist in an understanding of the fact that the force between colliding cars is not governed or in any manner reduced by the action of a friction gear

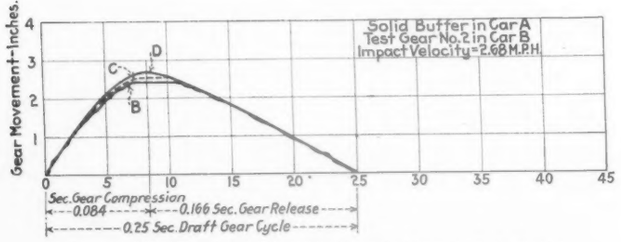


Fig. 4—Time-Closure Curves, Westinghouse D-3 Gears

over a spring gear of the same characteristics. Energy absorption has in itself no effect whatever upon the compression line. But its influence is immediately apparent in the forces of release. For while it requires high forces to overcome the frictional resistance and to compress a friction gear, the force immediately disappears when the gear starts to release. This action is clearly shown in the time-force curves.

Time-Closure Curves

Time-closure curves are developed for each of the runs, Fig. 4 showing such a curve for the single gear run for the Westinghouse D-3 gear. Curve D in this figure has been derived and erected from the superimposed car-movement curves and shows the full yield that took place between the cars, including draft gear compression, center sill compression, and side sill movement. Curve C is obtained by subtracting from Curve D the amount of the center sill yield and side sill movement. Curve C therefore represents the amount of and nature of the true draft gear action, all other influences being eliminated. Curve B was obtained from an entirely different source, namely, from the small drum carried by car B for recording the action of the draft gear in that car.

The time-closure curves of the runs in which both cars were equipped with draft gears showed that the two gears did not act in an entirely uniform manner, but that occasionally one of the gears would cease acting for an instant while the other moved. At other times both gears were acting. This character of action occurred both on compression and release, and was visible to the eye when closely watching the movement of the buffers.

Force-Closure Curves

In Fig. 5 is shown a force-closure curve for the closing run of Westinghouse D-3 gear (single gear run). This curve is produced directly from the time-force curve, Fig. 3, and the time-closure curve, Fig. 4, by eliminating the time element from both of these curves and plotting the force directly

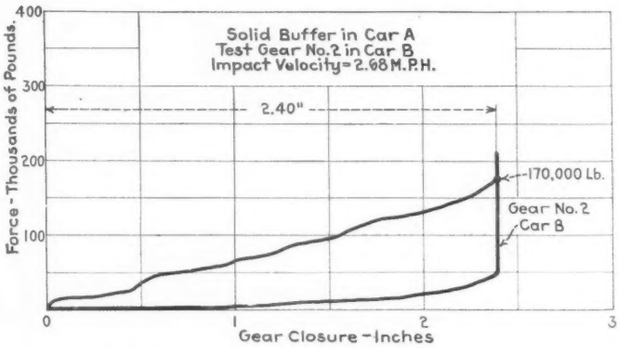


Fig. 5—Force-Closure Diagrams, Westinghouse D-3 Gears

against gear closure. The diagram corresponds with the ordinary static card except that it represents the dynamic action of the gear.

The amount of work done and work absorbed may be

CLASSIFICATION OF GEARS ACCORDING TO CLOSING SPEED

Class 1: Gears closing at 5 M.P.H and over
- National Type H-1.

Class 2: Gears closing at from 4 to 5 M.P.H.
- Sessions Type K.
- Miner Type A-18-S.
- Westinghouse Type NA-1.
- National Type M-1.
- Sessions Jumbo.
- National Type M-4.

Class 3: Gears closing at from 3 to 4 M.P.H.
- Cardwell Type G-18-A.
- Cardwell Type G-25-A.
- Westinghouse Type D-3.
- Gould Type 175.
- Christy.
- Miner Type A-2-S.

Class 4: Gears closing at less than 3 M.P.H.
- Waugh Plate.
- Bradford Type K.
- Harvey, Two 8 in. by 8 in. springs.
- Coil Springs, two 8 in. by 8 in., Class G.

figured from this card in the same manner as from the ordinary static card, these figures being given in later tabulations.

A series of runs was also made with both cars equipped with solid steel blocks in place of draft gears to determine the yield of the center sills, the whip of the side sills and the work absorbed by the car bodies and the lading.

CLASSIFICATION OF GEARS.	MAKE AND TYPE OF GEAR	TEST GEAR NUMBER		ACTUAL VELOCITY M.P.H.			SEISMOGRAPH READINGS		DISTANCE CARS TRAVELED FROM POINT OF IMPACT FT.		AMOUNT OF DRAFT GEAR CLOSURE INCHES.		YIELD OF TWO CAR BODIES - INCHES.	TIME - SECONDS			TRACK MOVEMENT OF CARS DURING D.G. CYCLE - INCHES	KINETIC ENERGY IN CARS FT. LBS.			ENERGY LOSS DURING D.G. CYCLE FT. LBS.	DETAILS OF ENERGY LOSS FOOT LBS.			ENERGY RETURNED BY 2 DRAFT GEARS FT. LBS.	WORK DONE BY 2 DRAFT GEARS FT. LBS.	ABSORPTION EFFICIENCY OF GEARS	FORCE TRANSMITTED TO CAR SILLS BY DRAFT GEARS. LBS.
				IMPACT CAR A	PARTING									COMPRESSION	RELEASE	TOTAL OF D.G. CYCLE		AT IMPACT	AT PARTING			TRACK AND GRADE RESISTANCE	ABSORBED BY 2 CAR BODIES	ABSORBED BY 2 DRAFT GEARS				
		CAR A	CAR B		CAR A	CAR B	CAR A	CAR B	CAR A	CAR B	CAR A	CAR B						CAR A	CAR A	CAR B								
		(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)
5 M.P.H. AND OVER	NATIONAL H-1	30	29	5.07	1.25	3.70	5.9	6.0	10'-1"	43'-2"	2.46	2.59	17	.091	.155	.246	10.5	12630	7639	6200	5461	2133	7828	41500	2867	54367	76 %	550000
4 M.P.H. TO 5 M.P.H.	SESSIONS K	12	11	4.37	1.27	2.95	4.4	4.2	12'-11"	29'-6"	2	2.06	31	.095	.187	.282	10.7	93820	7930	42850	43040	2213	8077	32750	5983	38733	85 %	260000
	MINER A-18-S	24	23	4.46	1.17	3.19	4.6	4.4	11'-1"	37'-10"	2.61	2.61	17	.098	.207	.305	11.7	97800	6760	50050	40890	2617	11706	26667	10766	32433	71 %	390000
	WESTINGHOUSE NA-1	8	7	4.16	1.22	2.80	4.1	3.8	12'-11"	27'-10"	3.05	2.91	16	.124	.287	.411	14.8	85100	7320	38410	39370	3268	2669	33433	4901	38334	87 %	187000
	NATIONAL M-1	33	32	4.26	1.21	3.18	4.3	3.9	11'-5"	32'-5"	2.61	2.61	19	.104	.231	.335	12.4	83551	7203	40076	40312	2805	3940	33561	6433	40000	84 %	404000
	SESSIONS JUMBO	15	14	4.30	1.01	3.20	4.7	4.4	9'-9"	31'-8"	3	2.83	17	.121	.226	.347	13.8	90740	5030	50080	35680	3105	3922	28633	9417	38050	75 %	250000
	NATIONAL M-4	36	35	4.12	1.22	2.76	4.1	3.7	12'-3"	26'-9"	2.55	2.42	13	.111	.244	.355	12.7	83610	7330	37600	38630	2910	4127	31633	5300	36933	86 %	159000
3M.P.H. TO 4M.P.H.	CARDWELL G-18-A	21	20	3.85	1.19	2.49	2.9	2.8	12'-4"	25'-9"	3.21	3.21	16	.144	.358	.508	16.7	72930	6946	30508	35476	3437	889	31150	3083	34233	91 %	186000
	CARDWELL G-25-A	18	17	*4.05	1.22	2.67	3.7	3.3	12'-6"	28'-6"	2.73	2.79	14	.116	.280	.396	14.0	80638	7317	35131	38190	3086	4037	31067	4766	35833	87 %	315000
	WESTINGHOUSE D-3	3	2	3.65	1.01	2.42	3.1	3.1	9'-4"	24'-6"	2.52	2.43	11	.112	.235	.347	10.9	65437	5235	30338	29864	2329	3202	24333	5000	29333	83 %	240000
	GOULD 175	42	41	3.56	.80	2.66	3.5	3.4	6'-0"	26'-11"	2.57	2.40	18	.114	.213	.327	10.0	62295	3124	34648	24523	1928	2395	20000	7334	27334	73 %	260000
	MURRAY H-25	39	38	3.45	.91	2.32	2.6	2.6	7'-5"	21'-7"	2.76	2.45	16	.127	.270	.397	11.6	58419	4105	26584	27730	2588	1975	23167	4633	27800	83 %	210000
	CHRISTY	53	52	3.73	1.09	2.44	3.1	3.2	11'-9"	23'-2"	2.07	2.23	17	.104	.235	.339	11.1	68230	7018	29186	32026	2295	7914	21817	4050	25867	84 %	194000
	MINER A-2-S	27	26	3.21	.88	2.12	2.0	1.8	7'-0"	17'-0"	2.59	2.45	27	.138	.287	.425	11.6	50615	3760	22101	24754	2560	5367	16833	3217	20050	84 %	105000
LESS THAN 3M.P.H.	WAUGH PLATE	50	49	*3.02	.43	2.52	2.8	3.0	23"	24'-4"	2.32	2.30	16	.116	.176	.292	7.6	44866	928	33120	10818	1483	1102	8233	9967	18200	45 %	335000
	BRADFORD K	47	46	2.78	.28	2.37	2.5	2.2	14"	21'-2"	2.52	2.38	16	.137	.186	.323	7.6	37827	397	27695	9835	1482	4053	4300	9366	13666	31 %	270000
	HARVEY 2-6"x8" SPGS.	56	55	2.33	.32	1.92	1.7	1.6	16"	14'-9"	1.97	1.76	12	.117	.179	.296	5.9	26647	523	18050	8074	1328	1329	5417	4566	9983	54 %	300000
	COIL SPGS. 2-6"x8" CL. G.	59	58	1.84	0	1.71	1.0	1.0	6"	10'-4"	1.94	1.86	01	.175	.181	.356	5.7	16666	0	14461	2205	1279	26	900	7333	8233	11 %	60000

Fig. 6—Tabulation of Car-Impact Tests. Closing Speed Runs. Double Gear Tests. 143,000-Lb. Cars.

Summary of Car-Impact Tests

The general tabulation, Fig. 6, has been prepared to summarize the actual performance of the test gears in the closing-speed double-gear runs of the car-impact tests. In this tabulation the gears appear in the order of the closing speeds of the commercial gears and have been classified according to closing speeds. In studying the performance of the car and the action of the gears there is but little interest in comparing a low speed gear with a high speed gear. The interest lies in comparing the action of and the results from the use of gears of different types and of approximately equal capacities. To facilitate such comparisons the various gears have accordingly been grouped into the four general classes shown in the accompanying tabulation.

While the Cardwell G-25-A test gears actually closed at 4.05 M.P.H., yet the average commercial gears of this type properly fall in Class 3, and this gear has accordingly been entered in this class in the general tabulations. Likewise the test gears of the Waugh type actually required 3.02 M.P.H. to close them, but from the average commercial gear this type belongs in Class 4. Asterisks (*) have been placed opposite these gears in the tables because of this fact. These tables need no special explanation.

Results to Be Expected from Commercial Gears

In Fig. 7 are shown energy curves for cars of different

weights, the rotative energy or fly-wheel effect of the wheels and axles, which amounts to an addition of approximately 3 per cent, being included. Horizontal lines representing the closing points of the various gears have been located on this diagram so that the value of any gear upon cars of the different weights may be readily obtained. These horizontal lines for the several gears are based upon the action of the average commercial gear. By means of this diagram the application of the results may be readily converted from a specific case to general cases.

Grading of Average Commercial Gears

Any one familiar with draft gear operation and testing can from the foregoing results, establish his own rating of the gears. The relative total merits of the types will differ, depending upon the importance attached to the several features of gear action. No one gear excels in all points. One repre-

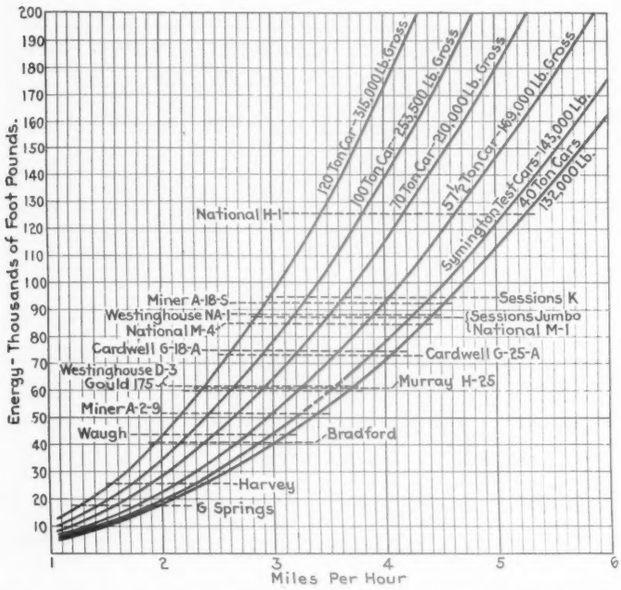


Fig. 7—Energy Curves for Cars of Various Weights, with Commercial Gear Capacities Indicated

sents the highest capacity; another the highest percentage of absorption; another the highest degree of smoothness of action.

The tabulation, Fig. 8, has been prepared on the basis of the following relative weights or percentages for the several phases of gear performance:

Capacity	50	points
Smoothness of action	15	"
Closing pressure	5	"
Absorption	15	"
Oversolid sturdiness	10	"
Workmanship and general operation	5	"
Total	100	"

The gradings on the above basis are made directly from the test results, except for the last item of five points, which represents those features that it is impossible to denote in abstract figures.

Comparison of the Different Methods of Testing

In most gears a wide difference appears between the static test results and the dynamic results, but in general there is not a wide difference between the drop test results and those in the car-impact tests. Static tests in general are usually made to determine the ultimate resistance of the gear, and the work done and work absorbed. It has generally been supposed that the character of the compression line was indicated by the static tests. These present tests show that the static test is not a measure, either absolute or comparative, of work done, work absorbed or ultimate resistance. For example, in the static test the Westinghouse D-3 gears averaged 18,550 ft. lb. of work done, while in the drop test the average work done was 15,375 ft. lb., the static capacity being 12 per cent higher than the drop capacity. On the other hand, in the National M-1 gear the static result is 263 per cent higher than that of the drop test. No uniformity whatsoever obtains in this percentage.

With some few exceptions, the drop test results, as to capacity and absorption, show a fairly uniform relationship to the car-impact results, the latter in general being from

Classification of Gears	Make and Type of Gear.	Capacity. 50 Points.	Smoothness. 15 Points.	Ultimate Force E. 5 Points.	Absorption. 15 Points.	Sturdiness. 10 Points.	Workmanship and General Operation. 5 Points.	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Class 1 5 M.P.H. & Over	National H1	50	7	3	12	10	5	87
Class 2 5 M.P.H. To 4 M.P.H.	Westinghouse NA-1	36	15	4	15	3	5	78
	Miner A-18-S	38	8	3	13	6	5	73
	National M1	36	9	3	13	7	5	73
	National M4	35	8	5	14	5	5	72
	Sessions Jumbo	36	9	4	13	3	4	69
	Sessions K	38	2	4	13	1	2	60
Class 3 4 M.P.H. To 3 M.P.H.	Cardwell G-25-A	30	11	4	15	2	3	65
	Cardwell G-18-A	30	9	4	15	2	4	64
	Westinghouse D3	25	11	4	14	3	5	62
	Murray H-25	25	10	4	14	3	4	60
	Miner A-2-S	21	10	5	14	5	5	60
	Gould 175	25	8	3	12	3	4	55
	Christy	24	5	4	14	6	1	54
Class 4 Less than 3 M.P.H.	Waugh Plate	18	10	1	8	2	5	44
	Harvey 2-8" x 8" Springs	10	5	1	9	3	5	33
	Bradford K	16	7	2	5	1	1	32
	Coil Springs 2-ARA-Class G	7	4	3	2	2	5	23

(A word of caution is necessary in using this table. While in most cases the results of the tests are believed to be representative of the action of the commercial product, certain exceptions are noted: namely, Cardwell G-25-A, Murray H-25, Bradford K and Christy.—Editor.)

Fig. 8—Grading of Gears, Based Upon Performance of New Commercial Gears

5 per cent to 20 per cent higher than the drop test results. The drop test accordingly would appear to be a fair comparative measure of draft gears for capacity and absorption.

The following general conclusions are drawn from a comparison of the action of the gears throughout the different tests:

1. That the speed of static testing within the limits of the average testing machine has in general but little influence upon the ultimate resistance of the gear.

2. That gears of a type may vary greatly in the static test and at the same time be of approximately equal capacity under the drop.

3. That the static capacity of a gear is no indication whatsoever of its dynamic capacity.

4. That in general, friction gears show greater capacity and higher ultimate resistance in the static test than in any other test.

5. That the ratio of ultimate resistance to work done varies but slightly as between different gears of the same type in the static test.

6. That the ultimate resistance in the static test and in the car-impact test is in general closely proportional to the work done by the gear in these two tests.

7. That the ultimate resistance in the car-impact test and the computed ultimate resistance in the drop test are in reasonably close proportion to the relative amounts of work done by the gear in these two tests.

8. That in the majority of cases the static curve shows the characteristics of the dynamic action of the gear, but that it is not a true measure of its dynamic capacity or ultimate resistance.

9. That the drop test, with a single gear supported upon the solid anvil, is in general a fair comparative test of gears as to dynamic capacity.

10. That the car-impact results will in general be greater than the drop test results by from 10 per cent to 20 per cent.

11. That the relative recoil of gears may be satisfactorily measured under the 9,000 lb. drop.

12. That neither the drop test, the static test, nor any other test using inelastic means for closing the gear will disclose roughness or irregularity of gear action: That tests upon a resilient body such as a standard car will alone disclose this feature of gear action.

The car-impact tests themselves have established and confirmed numerous principles of gear and car action, among which may be noted:

1. The relative merits of the different methods of draft gear testing.

2. The exact impact velocities at which the various gears will cease to offer further protection to the cars.

3. The production of complete dynamic cards of gear action.

4. The independent and inharmonious action of gears when dynamically closed in opposition to each other.

5. That gear action and car action in practice are not smooth and regular, even with the best friction gears.

6. That a friction gear is necessary for obtaining capacity and for eliminating recoil.

7. That the yield of the car structure and the lading do not afford any material aid in the dissipation of energy, and that friction draft gears in modern cars are essential to avoid high forces and early failure of parts.

8. That preliminary spring action shows no especial value in buffing and that heavy initial gear compression is not disadvantageous.

9. That the force developed between cars in buffing is due to the inertia of the cars, and when the slack is not bunched is the same whether the struck car be standing alone or whether it be at the head of a draft of cars; that the force is practically the same whether the struck car be standing with or without the brakes set.

10. That there is a positive displacement of the center sills relative to the side sills of a car, the amount of which is dependent upon the character of the construction tying these members together.

11. That in a modern steel car, a force equal to the ultimate resistance of the highest capacity gear in these tests will be developed between cars, without draft gears, at an impact velocity of 1½ miles per hour.

12. That if a gear is properly constructed as to sturdiness it requires but a slight over-solid speed to produce a high force peak; conversely, if a gear is not sturdily constructed an over-solid blow may never produce a high force peak, but such over-solid blows will quickly deteriorate the gear, and so reduce its efficiency that low impact speeds will cause damage to the car.

13. That the average period of draft gear compression with a friction draft gear is equal to approximately 1/3 of the entire cycle of impact and that the release occupies approximately 2/3 of the cycle. The maximum period of impact experienced was approximately ½ second.

14. That with a spring draft gear the period of compression and of release are approximately equal and that the spring returns practically all of the energy, bringing the striking car to complete rest and imparting almost the original velocity of impact to the struck car.

15. That several acceptable draft gears are now available capable of protecting a 57½-ton car up to a switching speed of 4 M.P.H. Furthermore, that there is not an occasion for higher switching speeds than 4 M.P.H.

General Deductions

From the tests as a whole the following general deductions can now be made and are recommended by the Inspection and Test Section of the United States Railroad Administration:

1. That for use on any car a gear should be selected which will not go solid at less than 3½ M.P.H. nor more than 4½ M.P.H. when the weight of the particular car to which it is to be applied is considered together with the complete information given in this report.

2. That there is no advantage in buffing from preliminary spring action, and that a draft gear should preferably be under some initial friction compression; not only for the increased capacity effected, but also to hold the friction elements in positive engagement at all times, in order to provide a greater latitude of wear and to prevent the deposit of foreign material upon the friction surfaces.

3. That draft gears should have an effective area for receiving over-solid blows slightly greater in extent than the area of the coupler shank; that this area should be presented in direct line with the force and should preferably be relieved of all other draft gear forces.

4. That all gear units should be of interchangeable dimensions and of equal travel. That considering the results of the high capacity Miner and National gears of 2½ in. travel, both in new condition and after prolonged service, together with the results from the Westinghouse NA-1 gear which is also of high capacity and of 3 in. travel, it is believed that the maximum travel figure of 2¾ in., as set by the Committee on Standards of the United States Railroad Administration, might well be set as a fixed and required standard travel for all new gears.

5. That from this standpoint of satisfactory operation there is no reason why a draft gear of 2¾ in. travel should not be designed with an ultimate dynamic resistance of 500,000 lb., provided the rate of increase of resistance is uniform throughout the travel of the gear.

6. That no gear should be of a greater capacity at this travel than will close at an impact velocity of 5 M.P.H., with 57½-ton cars, or show a greater drop test capacity than 25,000 ft. lb. Such a gear will close in a 120-ton car at 3½ M.P.H.

7. That the expression, "a draft gear of 150,000 lb. capacity," is erroneous and should not be used; and that the ½-in. rivet shearing test as used to define the above expression should be abandoned in favor of regular 9,000-lb. drop tests, or preferably car-impact tests, until such time as a more convenient test for smoothness of gear action can be developed.

8. That the American Railroad Association should provide itself with a gravity car testing plant of the general character of that used for these tests, whereupon to conduct such draft gear and car construction tests as may be desired.

Scheduling and Routing Systems for Car Shops

Applying Methods Used in Locomotive Work to Freight and Passenger Car Repairs

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MANY forms of scheduling and routing systems have been developed and successfully installed in locomotive repair shops but, to date, very little has been offered as a guide for applying these principles to car repairs, either passenger or freight. Fundamentally, such systems are very similar in outline and application and there is no valid reason for assuming that a system which has greatly benefited a locomotive repair shop will not give equally good results in a car repair shop. The quality of labor employed and the quantity of cars repaired automatically induce systematic operating methods.

The essential features in the installation of scheduling and routing systems in locomotive repair shops may be briefly reviewed as follows:

(1) A supervisor or schedule man and one or more assistants are required, the supervisor to report directly to the general foreman or shop superintendent.

(2) A suitable office should be provided in the shop proper, centrally and conveniently located.

(3) Master schedules, as necessary, covering the principal types of equipment and classes of repairs are prepared.

(4) Shop sheets or order-of-work slips are issued to foremen, conveying the dates assigned by the application of master schedules.

(5) Delay or progress sheets are drawn up giving those in authority details covering causes for delays and time lost on master schedule allowances.

(6) Schedule boards in the supervisor's office, record all information previously issued to foremen on shop sheets. delays are posted on these boards, which finally present a complete record of all scheduling and routing work, together with the output of all departments involved.

Applying the Principles of Scheduling to Car Work

The above fundamentals may now be examined with reference to their applicability to car repairs. The supervisor of car schedules should be a man with practical experience, having preferably served some time, or an apprenticeship, in several car shop departments. He should be of an executive type with initiative and aggressiveness. The clerical type of supervisor is not usually as successful, from the fact that the main objective is co-ordination of all working forces to the common end—*Output*. The supervisor may have one or more assistants, depending upon the size of the plant, and these men can handle all clerical details. In very large shops it is desirable to employ a man carrying the title of production engineer or shop specialist, who would have charge of all scheduling and routing methods in all departments of the plant.

It is important to have the schedule office located in the shop. It may best form a part of the general foreman's office or open into it. Foremen should be free to discuss matters frequently with the schedule supervisor and visit the office to examine their department records as shown on the schedule boards. The schedule supervisor is essentially a shop officer, ranking with and having a common interest with the foremen. Their close co-operation is not only desirable but imperative if the best results are to be obtained. In some shops it may be convenient to consolidate the locomotive and car department schedule offices, but for most efficient operation the car department office should be located in the car shop.

Preparing Master Schedules

Master schedules for locomotive repairs are now pretty generally standardized. About 50 important operations are listed in order of occurrence and a date or day of the month assigned for each. Different classes of repairs require separate schedules, longer or shorter; also different types of equipment may influence the assignment of dates or operations. In general the master schedule is a simple list of operations stated in the order in which the work is to be performed. Master schedules also list the principal items or groups of material and assign dates when such parts are wanted in the several departments of the shop.

It is not difficult to apply master schedules to passenger or freight car repairs. For passenger cars the type and number of car and class of repairs should be noted, also the estimated date on which repairs should be completed, and the number of the schedule which applies. A convenient

form of master schedule for passenger car repairs would show the exterior and interior repairs and painting work separately. For example, a 1-A-2 repair would mean Class 1 or "heavy" exterior repairs, Class A or "heavy" paint repairs and Class 2 or "medium" interior repairs. Any convenient combination of numbers and letters will be found useful in assigning correct master schedules to suit the nature of the repairs indicated by a close inspection of the car considered.

Painting work governs passenger car repairs to a large extent and master schedules should be selected only when recommended by the shop foreman. The carpenter work must be finished before paint is applied but the days required for painting operations is the principal consideration when applying a schedule. Painters' work, when applied to heavy car repairs, usually requires so much time that work on other parts such as air brake, truck, electric wiring, heating, fixtures, sash, upholstery, etc., can be made ready during or soon after painting, varnishing, etc. For heavy repairs to a passenger coach, requiring perhaps about 16 days in the shop, the master operation schedule should carry about 15 items for checking the various classes of paint shop work applicable to the inside and outside of the car. Other work, as indicated above, will require about ten items on this schedule. "Constants," as now generally understood and used in locomotive shop practice, are also applied to passenger car master schedules and the shop sheets may be filled out with actual dates for foremen by using a special slide rule, if desired, exactly as is done with locomotive shop schedules.

Methods of Handling Shop Sheets

Shop sheets or order-of-work slips are simply complete master schedules split up, the proper portions being delivered to the departments interested. Shop sheets carry exact dates, or days of the month, in place of the "constants" or constant intervals of time (represented by days) shown on master schedules. These shop sheets are handled exactly as in locomotive practice. In some shops small blackboards are used in place of shop sheets, or information from shop sheets may be copied upon special forms bulletined in the foreman's office. One large passenger car shop has found it good practice to hang a general shop sheet, carrying information for all departments, on the end of the car being repaired. Foremen can then see at a glance in what order their work is scheduled and the status of the repairs may be checked quickly by supervisors and those in higher authority. Sub-departments located some distance from the car repair shop proper should have their order-of-work sheets delivered, since much time would be wasted by men from these departments visiting the car for purpose of learning work assignments from the general shop sheet.

Delay sheets, or progress reports, assume the same form as those already described in numerous published articles outlining systems for locomotive repair shops. What is needed simply is a record showing the number of days each operation or material item is late on the time allowance designated by the standard master schedule. Such delay sheets are preferably issued daily to the foremen of delinquent departments, copies going to the general car foreman, master mechanic or superintendent of shops. Delay sheets must be accurate and immediate if beneficial results are to be obtained. Delays are posted, usually with red ink, on the supervisor's schedule board exactly as in locomotive practice. A general analysis of the recapitulation of delays by departments and schedules, monthly, is of value to those in higher authority when periodical or habitual weaknesses occur. Other important situation statements may be made from data carried on schedule boards as desired. These comparative records assume the form of "delay days per car dispatched," "delay days per department" or "per cent of delay days per department," etc. Such competitive records are not punitive but stimulate effort and furnish correct information for use in adjusting the shop design, equipment or organization.

A successful passenger or freight car schedule system is to a considerable extent dependent upon operations outside of the immediate working organization. Proper switching of cars, layout of tracks and shops all have a bearing upon the schedule plan. Cars entering the shop for repairs should be separated into heavy, medium and light classes and, if possible, segregated on tracks so arranged that a minimum amount of lost motion, either with men or material, is assured. Passenger cars with exteriors finished should be set outside of shop as early as possible to provide shop track space and interiors may be completed when the car is outside and under steam. In large plants gang work on passenger cars is to be recommended, but this organization feature is not emphasized to the extent described later for freight equipment shops.

Scheduling Freight Car Repairs

Proper scheduling and routing of freight equipment is, perhaps, the most difficult problem of all. Freight car repairs not only occur in great numbers, but are of many types and classes. It is only feasible to consider scheduling the heavy repairs, for example those requiring over 20 man-hours, and in any event the items scheduled must be boiled down to the least number possible and still be of sufficient importance to justify the scheduling and routing work. The supervisor and his office will generally conform to what has already been said with relation to passenger cars. In most cases one office for the entire car department will be found adaptable.

Master schedules for repairing freight equipment, because of faster deliveries, must carry smaller intervals of time than for locomotives and passenger cars. "Days" and "hours" must be substituted for "days" only as heretofore. A master schedule might be made to cover a heavy repair requiring, say, 40 man-hours, or one man five days. Operation items must be cut down to ten or fifteen important work classes such as "Car in Shop," "Stripped," "Sills O. K.," "Draft Rigging O. K.," etc., to "Car Painted" and "Out of Shop." Perhaps a date for the work of each special gang would be sufficient. It is not now considered necessary to make out master schedules for individual cars, and the small scheduling force could not possibly take care of a shop delivering 300 heavy freight car repairs a month if each car were assigned a special schedule. Schedules should preferably be made to cover groups of cars and all cars in a group should require repairs of such character that one general schedule is found sufficient.

Routing Material

Material for repairs may be handled by a separate system controlled by the schedule supervisor. One large car repair shop has a material routing plan which operates as follows. An assistant foreman in the main repair shop inspects entering cars and lists all material needed for making repairs. This list is written up on a special form or order which is taken up by supply men at frequent intervals daily. The material routing clerk receives copies of these orders and periodically checks all departments, visited by supply men and also checks material arriving at destination in the main repair shop. Records of delays by departments and delays for which supply men are responsible are tabulated in the clerk's office and subsequently forwarded to the general foreman or shop superintendent for their information and action.

Group Schedules for Freight Cars

It may be well to refer further to the group idea for freight car schedules in contradistinction to the individual unit schedule applied to locomotives and passenger cars.

Incoming cars may be switched to tracks so arranged that similar classes of heavy repairs are segregated as far as practically possible. For example, a group of ten box cars which require from 40 to 80 man-hours each for complete repairs are located on track number 1 in the shop. A master schedule may be made up by the supervisor in such manner that this track of ten cars may be switched completed on the same day, or two consecutive days. Although these cars are estimated to require repairs extending over periods of five to ten days for one man, yet they will all probably go out in three or four days when all gangs work continuously on them. The master schedule for this ten-car group would then be made up for the average time allowed, say three and one-half days, and the major items of work scheduled in proper sequence in the same manner as for any other class of equipment, except that time allowances are given in hours. It may be found desirable to bulletin a general or track shop sheet in some convenient location where all foremen can keep posted regarding the schedule allowances for their gangs. Duplicate sheets may be given foremen of departments whose headquarters are some distance from the main shop.

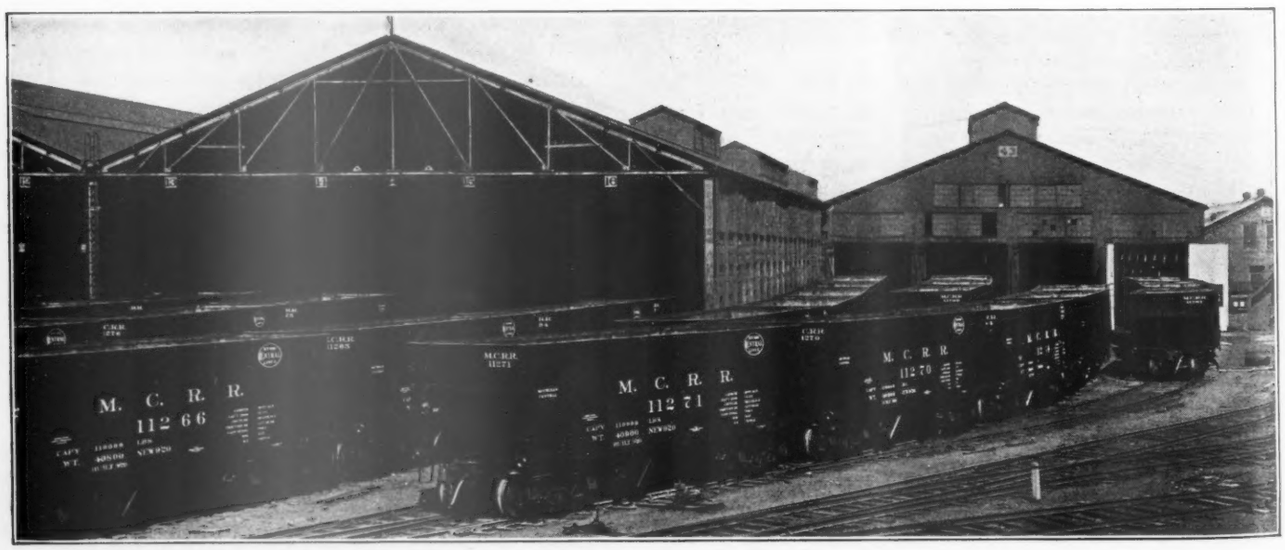
Moving Gangs vs. Moving Cars

Daily delay sheets should be issued covering each track or group of cars exactly as done for passenger car units described previously. The most successful freight car scheduling is obviously dependent upon large operations, sufficient material and supplies, and a complete organization which will enable men to be highly classified into special gangs. One large railroad has developed the gang plan as follows. Incoming cars are switched to several adjacent tracks, care being used to separate cars by repair and equipment classes as far as possible. Specialized gangs begin work on track number 1, when work is finished they pass to track number 2 and so on to the last track. Each gang is scheduled and checked for the number of hours allowed for doing the work on all of the cars on each track. A delay sheet, for example, might read partially as follows: "Gang number 2, stripping, track number 3, 1 hour late," etc. There should be a stripping gang, sill gang, draft rigging gang, paint and stencil gang, etc., as found best suited to local conditions. Specialized working gangs eliminate dead time and many large car shops have demonstrated that, as in locomotive shop practice, the use of groups of men or gangs always results in increased output with lowered costs. Scheduled shifting gangs will enable the supervision to easily check up their men, locating them on a certain track at a stated time.

Some freight car shops have adopted an opposite plan by having the gangs stationary and moving the cars. Cars are switched to tracks, separated by repair and equipment classes and scheduled in the same general manner as outlined in preceding paragraphs. As fast as one class of work on a car is completed by a gang, it is moved forward to the next gang organized to handle the repairs needed. Objection may be raised that frequently switching or moving cars adds to the expense, but this may be offset to some extent by savings incident to permanently located riveters, forges and other heavy tools and appliances. It is possible that men may wait for work in some cases or for a car movement, thereby losing time which possibly would not develop if the gangs moved and the cars remained stationary. These two plans should be thoroughly tested and data furnished which will definitely state the advantages and disadvantages of each and make positive recommendations for future guidance.

There is no question regarding the advisability of extending practical, up-to-date scheduling and routing methods to passenger and freight car repair shops. Just what form the necessary schedules and sheets will finally assume has not yet been thoroughly worked out and published. It is not difficult to handle the car department situation, but some tracks must eventually be relaid, cars must be more carefully grouped and spotted and more special gangs organized. There is a large field for thought and careful planning when designing new shops to provide proper tracks and facilities which will co-ordinate with production systems or schedules best adapted to maximum output at minimum cost.

On the basis of experience with electric traction on the Norfolk & Western, the American Railway Engineering Association's Committee on Electrification concludes that 44,000 volt current for transmission and 11,000 volt single-phase current for the overhead line are practicable for lines having heavy gradients and heavy traffic, and that probably this system will effect a saving of at least 12 per cent of the total annual expenditure as compared with steam operation.



At the McKees Rocks Plant of the Pressed Steel Car Company

Some Failures of Chilled-Iron Car Wheels*

Chemical Specifications Proposed to Improve Service—Importance of Low Percentage of Phosphorus

BY H. J. FORCE

Chemist and Engineer of Tests, Delaware, Lackawanna & Western

THE cast iron wheel has a marvelous history. Approximately 26,000,000 chilled-iron wheels are now in use in the United States and Canada, under freight cars, passenger coaches, refrigerator cars, engine tenders, city street cars, interurban cars and electric locomotives. Eighty to ninety per cent of all the equipment in the United States and Canada is equipped with cast iron wheels. The annual production in the United States is approximately three million wheels, some of which are exported to France, Russia, Italy and other foreign countries. A large proportion of the total production is required for repairs.

It is the object of this paper to point out such recommendations and changes as are thought to be necessary in the chilled-iron wheel. It is well known that during the past few years railway cars have been loaded to greater capacity; heavier equipment has been placed on many lines; many roads are using rails much heavier than a few years ago; roadways are rock ballasted, and are very largely equipped with tie plates. This rigid track construction has placed a greater duty upon the chilled-iron wheel, a condition which it is felt the manufacturers possibly have not realized, for little or no effort has been made to improve the quality of the wheels to meet these severe conditions.

The cast iron wheel is about the only part of railway equipment which is not purchased to a chemical specification; yet it is the most important part of such equipment. The failure or breakage of one wheel in a train almost invariably results in derailment. Such chemical specifications as have been recommended are not generally acceptable both to the manufacturer and the consumer. It is generally conceded that unless an improvement is made in the quality of cast iron wheels, the railway lines will be forced to give careful consideration to the use of steel wheels, with the hope that fewer failures will result in service.

A study of the service condition of cast iron wheels leads to the opinion that this wheel can be greatly improved, and that it will be found to be satisfactory under nearly all equipment. It has been claimed that the ordinary wheel on certain lines is satisfactory. This may be true where such lines do not have any lengthy and heavy grades, but where these grades do exist failures from cast iron wheels are constantly resulting; and as every class of equipment is handled over these lines, it is necessary that the wheels on all lines be made of the best possible composition.

During the year 1920, 42 failures occurred from broken wheels on the lines of the Lackawanna, and with very few exceptions these were on foreign cars. For 1921 14 failures have occurred which caused derailments.

TABLE I—WHEELS WORN OUT IN SERVICE

(All Values in Per Cent)

Mark	Cast	Total carbon	Graphitic carbon	Combined carbon	Phosphorus	Sulphur	Manganese	Silicon
A	9-20-15	3.31	2.32	0.99	0.360	0.154	0.49	0.70
B	6- 2-16	3.53	2.77	0.75	0.308	0.136	0.66	0.73
C	7- 2-13	3.17	2.18	0.98	0.304	0.155	0.55	0.65
D	8-24-12	3.08	2.15	0.93	0.260	0.122	0.43	0.59

Four wheels were selected from a number of wheels which had been worn out and marked A, B, C and D. Table I shows the date each wheel was cast, and gives the composition. It will be noted that in most cases these wheels meet the requirements of the specifications recommended later, although no effort apparently was made to make the wheels to any specification. The table shows the fact that the composition as to phosphorus and sulphur, and especially silicon, is fairly satisfactory. It should also be pointed out that the wheel with the lowest sulphur and lowest phosphorus apparently gave the best service. The higher silicon wheels in all cases showed more wear than lower silicon wheels. On the other hand, it is believed that the combined carbon content, which in one case is as high as 0.99 per cent, is outside the limit for a cast iron wheel which would give the best service.

TABLE II—WHEELS FAILED IN SERVICE

(All Values in Per Cent)

Mark	Cast	Total carbon	Graphitic carbon	Combined carbon	Phosphorus	Sulphur	Manganese	Silicon
1	8-27-17	3.24	2.24	1.01	0.420	0.176	0.57	0.70
2	.....	3.36	2.13	1.23	0.430	0.191	0.41	0.82
3	.....	3.35	2.46	0.89	0.440	0.200	0.65	1.06
4	4-15-18	3.37	1.87	1.50	0.384	0.182	0.39	0.75
5	5-28-13	3.34	2.19	1.14	0.388	0.199	0.52	0.75
6	3-28-18	3.34	2.10	1.24	0.386	0.146	0.36	0.76
7	6-28-20	3.22	1.91	1.31	0.354	0.193	0.52	0.80
8	8-21-19	3.20	1.99	1.21	0.384	0.261	0.67	0.88
9	3-14-18	3.19	2.24	0.95	0.364	0.171	0.50	0.84
10	3- 9-20	3.34	2.15	1.19	0.428	0.185	0.52	0.69
11	10-13-17	3.19	2.16	1.03	0.408	0.138	0.38	0.70
12	9- 3-19	3.33	2.24	1.08	0.370	0.197	0.60	0.76
13	12-30-18	3.32	2.34	0.98	0.420	0.175	0.79	0.73
14	.....	3.12	2.14	0.98	0.420	0.219	0.72	0.93
15	2-17-15	3.32	2.20	1.12	0.400	0.190	0.43	0.68

Table II shows a list of wheels which failed in service and in each case caused a serious derailment. Note here the high combined carbon, high phosphorus and uniformly high sulphur, in some cases low manganese, and in many cases high silicon. Wheels of this composition should not, under any circumstance, be placed in service. It will be noted that some of these wheels gave very little service, and it is safe to say that the wheels were shipped without the knowledge of the manufacturers as to their chemical composition.

Analyses were taken on a number of wheels made on different dates by three different wheel foundaries, the majority being cast in 1920. Foundry B was asked to furnish wheels with not over 0.35 per cent phosphorus, but analysis showed considerable high phosphorus. This was the first attempt of this foundry to make wheels to a chemical specification. The same request was made of foundry A, and in this case all wheels conformed to the specification as to phosphorus. In foundry N effort was then made to have the wheels contain not over 0.32 per cent phosphorus. In every case the wheels conform very closely to the specification, and it is felt that no undue hardship will be imposed upon the wheel makers to have phosphorus not over 0.32 per cent and that a better and safer wheel will in every case be produced.

It is not contended that a chemical requirement will at once eliminate all wheel failures, for it is possible that an occasional wheel will fail in service from inferior composition due possibly to some oversight on the part of a workman in the foundry.

In order to show the necessity for chemical requirements in a specification, attention is called to an analysis of 252 wheels from 28 different foundries that were being removed in our shop in the ordinary routine of operation. No selec-

*From a paper presented at the annual meeting of the American Society for Testing Materials, June 21-24, 1921.

tion whatever was made; the wheels were taken just as they came into the shop to be removed for the various causes cited below:

Cause of removal	Number of wheels	Average life
Brake burns	21	5 yr. 1 mo.
Cracked plates	61	4 yr. 5 mo.
Seamy rims	31	6 yr. 11 mo.
Worn flanges	56	7 yr. 8 mo.
Worn through chill	4	7 yr. 2 mo.
Shelled out	33	6 yr. 6 mo.
Seamy treads	4	4 yr. 0 mo.
Slid flats	35	3 yr. 4 mo.
Chipped rims	7	8 yr. 1 mo.
Total	252	

The average life of these 252 wheels was 5 years and 5 months. The total percentage of cracked plates in this lot is approximately 24 per cent. Taking this as an average, the total number of wheels removed for cracked plates during a period of twelve months on the Lackawanna would be approximately 8,000.

In our judgment, the cracking of plates is due very largely to inferior chemical composition. Seamy rims and seamy treads are as a rule due to foundry practice, and are usually the result of metal being poured at too low a temperature. It is hardly necessary to call the attention of the manufacturer to the necessity of immediate improvement in both manufacture and composition of cast iron wheels.

It is recommended that the question of drop test and thermal test be carefully investigated. We believe these tests should be made as severe as possible, so that none but good wheels may be shipped.

The Association of Manufacturers of Chilled Car Wheels has given assurance that the manufacturers are anxious to lend all possible assistance in the production of a first-class wheel. The following specification is therefore recommended, covering all weights of chilled-iron wheels:

SPECIFICATION A

	Per cent
Total carbon	3.00 to 3.65
Combined carbon	0.45 to 0.85
Manganese	0.50 to 0.75
Phosphorus	Not over 0.32
Sulphur	Not over 0.17
Silicon	0.45 to 0.75

It is felt that the heavier wheels which are now being recommended will have a further tendency to reduce failures.

It is recommended that special consideration be given to a wheel which contains a small percentage of nickel and chromium, as indicated in specification B. Wherever wheels of this composition have been placed in service, the results have been highly satisfactory; and the wheels should be especially suitable for the heavier equipment. The increased cost of these special wheels will run from seven to ten per cent.

SPECIFICATION B

	Per cent
Total carbon	3.20 to 3.75
Combined carbon	0.40 to 0.80
Manganese	0.45 to 0.65
Phosphorus	Not over 0.15
Sulphur	Not over 0.17
Silicon	0.45 to 0.70
Chromium	0.10 to 0.25
Nickel	0.10 to 0.20

Every wheel maker understands that while his metal may be of the proper composition, an inferior wheel can be produced due to faulty foundry practice, such as allowing wheels to be cold when pitting, or maintaining pits in improper condition. However, if the foundry practice is correct and the wheels are of the proper chemical composition, there is every reason to believe that a good, safe, cast iron wheel can be produced. The drop and thermal tests, together with an examination of the fracture and depth of chill, usually reveal the method of foundry operation.

The majority of the failures of wheels previously cited occurred near the bottom of long, heavy grades, probably due to the elevated temperatures which the wheels attained. In nearly all cases failure occurred by rupture of the plate, and it is important, therefore, that the composition be controlled so that as much strength as possible may be obtained and the wheel enabled to withstand the elevated temperatures developed on all heavy grades.

With the increase in weight of the wheel, the heavier plates and thicker flanges, there is good reason to believe that the cast iron wheel will continue to serve the railways of the United States for many years to come.

Standardizing Car Equipment

The National Association of Owners of Railroad Securities recently appointed a Board of Economics and Engineering to study the methods of effecting economies in the operation of the railroads. L. B. Stillwell, consulting engineer and one of the members of the board, in the hearings before the Senate Committee, presented the report of the board on the subject of rolling stock. Mr. Stillwell advocated having cars owned and maintained by an equipment corporation with a view to effecting standardization, improvements in design, construction and maintenance, and the stabilizing of orders and maintenance work. An abstract of the statements submitted by Mr. Stillwell is given below.

Among the objectives toward which the board has planned to direct its investigation and efforts, the following may be mentioned: (a) Further standardization of freight and passenger cars. (b) Stabilizing of orders for new equipment and for replacement and repairs. (c) Establishment of a system of periodic repairs of freight cars. (d) Strengthening or retirement of weak cars, or their restriction to local service on home lines.

FREIGHT CARS

Standardization of freight cars as affecting interchangeability has already been accomplished in large degree. The railroads are using, however, even in identical service, cars differing materially in strength, weight, capacity and durability.

From the experience gained in operating these cars, a limited number of standard types and sizes should be selected or developed for interchange service and thereafter adhered to, except in special cases where the reasons for deviation may unquestionably be controlling.

Standardization should not preclude development and improvement in design and material, but should secure interchangeability as regards component parts, and it should define minimum limits of strength of essential parts. This can be done without sacrificing the advantages of competition between manufacturers in the development and sale of their specialties, as the establishment of minimum limits in no way precludes progress by improvement of material or design within the dimension limits fixed by the interchangeability rule.

In selecting or developing standard cars, life and weight are of the greatest economic importance. For illustration, if the country has 2,500,000 freight cars and the average life is 20 years, 125,000 cars per annum must be purchased for replacement.

If the average life could be increased to 30 years, by improved design and systematic maintenance, the same result would be accomplished by purchasing 83,000 cars per annum. The difference, 42,000 cars, at present prices would cost about $100,000,000.

Broadly speaking, durability (life) points toward an increase of weight in design, but weight does not necessarily mean strength, and it is obvious that the interests of the railroads call for a complete study and action which will secure durability without excessive weight.

STABILIZING MAINTENANCE

A condition which results in a very great increase in cost of railroad operation exists in present repair practice, each road being supposed to repair all cars which develop the need of repairs while on its lines.

Obviously the best interests of the railway industry as a whole require that in slack periods when cars are plenty such cars should be put into good condition in order that they may be available when heavy traffic returns. Under present conditions, repairs are often postponed because of lack of available funds.

Relative Economy of Electric, Oil, Gas and Coal-Fired Furnaces*

BY T. F. BAILY†

Rapid elimination of natural gas as an industrial fuel and the rapid increase in the price of fuel oil, coupled with the statement of the United States Geological Survey that shortly it will not be available as an industrial heating medium, have brought the attention of the public generally to electric furnaces as one ultimate type of equipment that will combine not only accuracy of treatment to a degree which was never possible in fuel fired furnaces, but also reliability from the standpoint of supply of heat, as electricity has now become the most common of all commodities. It is true that there is a considerable thermal loss in the transformation of fuel to electric energy, nevertheless, the modern power plant is able to use the lowest grade of fuel; while the fuel used in industrial furnaces generally has been more expensive, as well as more difficult to obtain, as is evidenced by the gas and oil situation today.

From the standpoint of fuel conservation, it is of interest to note that even when taking into consideration the thermal efficiency of a modern power plant and distribution system of only 15 per cent, and an electric furnace efficiency of an average of 60 per cent, the net thermal efficiency for the entire cycle would be at least 9 per cent. On the other hand, assuming the same grade of fuel could be used conveniently in small industrial furnaces, which are now mostly fired by oil or gas, the efficiency probably would not run over 5 per cent, and probably it would require a higher grade of coal. Besides this, it would necessitate a modified design of furnace with a large combustion chamber. This would require a much larger floor space and would mean a complete new plant arrangement in most present installations. On the other hand, the electric furnace requires little more space than the present type of oil or gas-fired combustion furnace.

From a cost standpoint, it is difficult to make an accurate comparison, because of the wide variation in efficiency of the various fuel-fired furnaces; but taking as a basis, in the case of oil for heat treating operations, a consumption of 30 gallons of oil per ton of product, and with oil at 15 cents per gallon, which is the prevailing price at the present writing, the cost would be $4.50 per ton for fuel only.

With natural gas-fired furnaces, it is doubtful whether an efficiency of better than 6,000 cu. ft. of natural gas per ton of product can be maintained, and at a price of 50 cents per 1,000 cu. ft. the cost would be $3 per ton for fuel only. An electric furnace of the same capacity, which is taken as 1,000 pounds per hour, would consume not to exceed 300 kilowatt hours per ton of material heated, with an average fuel cost of 1¼ cents per kilowatt, which would bring the cost to $3.75 per ton for fuel only.

Thus it is to be noted that under average conditions on small sized units, which are the most common types found in the heat treating industry, there is not a great variation in fuel cost; and, after all, this is of minor consideration when compared with accuracy of treatment, in which field the electric furnace is pre-eminently fitted to produce the highest quality of material. This is especially true of the electric furnace when coupled with automatic control devices, either of the time element or pyrometer control type.

In the larger capacity furnaces handling several tons per hour, direct coal-fired or producer gas fired furnaces, which obtain their gas from soft coal, show much better economies; but in similar capacities, electric furnaces also show better economies. When taking into consideration the recuperative car-type furnace, the current consumption will fall when annealing larger tonnages of steel, to as low as 120 kilowatt hours per ton. This with current at one cent per kilowatt hour, the probable rate under such conditions would be $1.20 per ton for fuel, as compared with coal-fired furnaces with coal at $4.80 per ton. This would mean that from a fuel standpoint alone the producer gas-fired furnace would have to have a consumption of not to exceed 500 lb. of coal per ton of metal heated. Besides, the difficulty of obtaining the desired grade of coal to operate well in the producers; the additional labor cost for handling both fuel and ashes from the producer; and the much larger space required for both the producer and gas-fired furnace are disadvantages.

Foremanship a Profession

The art of successfully managing men surely requires as much tact and knowledge as is required by the average professional man. True, we are only just coming to a full realization of this, yet how little attention is given to the training of foremen and how little time the average foreman is able to give to study and research.

Are the managements not making a serious mistake in allowing the foremen to go ahead with blinders on, their views being restricted to narrow limits which do not include a large conception of the latent possibilities of the human element or the principles underlying efficient production?

*A paper presented by title at the Philadelphia convention of the American Society for Steel Treating.

†President, Electric Furnace Company, Alliance, Ohio.

From a labor standpoint the electric furnace requires the least attention. In some of the larger units used in heat treating, consisting of two furnaces and an automatic quench between, two men on the combined unit will handle as much as three tons of material per hour; while in nonautomatic plain hearth-type fuel-fired furnaces several times as many men would be required.

Still more important, it would be impossible to control in this hearth-type fuel-fired furnace, the heating cycle and the quenching conditions of the heat treating operation with anything like the accuracy obtained by the automatic electric equipment. In some operations, such as the annealing of high carbon high chromium steel, wherein a definite cooling cycle is required, the electric furnace offers substantially the only certain means of controlling this cooling cycle.

The comparison of the three types of furnaces may be briefly summed up in the statement that while no great difference exists in the actual fuel cost between the three, the electric furnace at the present time is the one that seems most certain of a continued and uninterrupted supply of fuel. In numerous cases the actual fuel cost may be higher with the electric furnace than by oil or gas; but for the accuracy of treatment and from a standpoint of cost per ton of material which actually meets the specified requirements, the electric furnace probably will be cheaper than any of the other types, and can be depended upon absolutely from a production standpoint.

A Surgical Operation Performed on a Locomotive Valve Port*

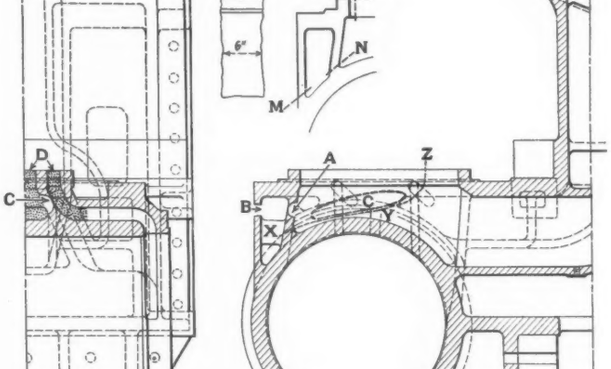
BY M. R. FEELEY
General Foreman, Delaware, Lackawanna & Western, Hoboken, N. J.

About fifteen months ago a slide valve locomotive operating on the Delaware, Lackawanna & Western out of Hoboken, N. J., was reported by enginemen as leaking steam under the cylinder jacket on the left side. Opening the steam chest and removing the main valve disclosed a cavity *A* in the cylinder wall which had broken through at this point. In the first attempt to repair the break a hole *B* was drilled in the outer cylinder wall large enough to allow for drilling, tapping and inserting a plug at *A*.

The locomotive was returned to service but in a short time was again reported as having a bad blow, this time apparently in the left cylinder packing. At the first opportunity the locomotive was returned to the roundhouse, the usual tests being made to locate the blow. Both the cylinder packing, valve seat and valve packing strips seemed to be all right and difficulty was experienced in finding the trouble until a light inserted in the exhaust passage flashed through into the steam port. This indicated plainly that the bridge between the two ports was defective but due to its position, the defect was not only difficult to see, but apparently impossible to repair by welding. The location of the defect is shown at *C* in both the side and end views of the cylinder. A careful inspection of the bridge showed that it was not in reality cracked but that the entire enclosed section marked *C* was thin and had broken through in one point. The cause of this thin bridge and also of the cavity at *A* was evidently a shifting of the core in originally casting the cylinder. As shown, the thin section extended over about two-thirds of the length of the bridge.

The difficulty of repairing this cylinder defect by welding was realized but in view of the great need for motive power at that time and also to save as much money as possible on the job, it was decided to see what could be done by welding, the following method being used. A six-inch section of the outer cylinder wall was cut out along the lines *M N P*. In addition a section of the bridge was chipped out along the lines *X Y Z*, in other words, down to a point where the bridge was of a normal thickness. The passages to the exhaust base and steam pipe were plugged and fireclay carefully packed in as shown at *D*, leaving a space where the original bridge had been. In order to secure a smooth job, the surface of the fireclay was covered with plastic carbon.

The next operation before attempting the actual work of welding was to pre-heat the cylinder carefully and thoroughly. This was done in the usual manner by building up a fire brick furnace and burning charcoal under forced draft. The entire cylinder was covered top and bottom and when the required temperature had been reached (preheating took about six hours) a few bricks were removed from the top of the valve seat leaving just sufficient space to get a torch down to the broken bridge. Two men using No. 15 tip oxy-acetylene torches were employed on the job, part of the time simultaneously and at other times relieving each other. Continuous use of the torches in a short time brought the base of the cast iron bridge to a plastic and finally a molten state. Small broken pieces of cast iron cylinder packing were then dropped into the space left for the bridge where they melted and became thoroughly mixed with the other iron, gradually building up the bridge to its original height. In order to secure a good wearing surface the last half-inch of the bridge was built up using special Norway cast iron welding rods. As the bridge was built up, the outer wall was also built up.



Side and End Views Showing Location of Cylinder Defects

The section of the outer wall previously removed was then fitted back in place and welded, thereby completing the welding operations. After all welding was finished, the cylinder having been maintained at a uniformly high temperature throughout, the cylinder was allowed to remain until the following morning without removing the fire brick furnace. The charcoal gradually burned out and by morning the furnace and cylinder were cool. This precaution was necessary in order to reduce internal strains to a minumum. The valve seat was re-faced, the main valve, steam chest and cover being applied and the motion work connected up. The engine was then returned to service and in the past fifteen months has given no trouble from this welding job.

In a discussion following Mr. Feeley's talk, the fact was brought out that this welding repair job saved time and considerable money over what it would have cost to apply a new cylinder. About 3½ days were required for making the repair and the cost was approximately $65 for labor and material.

*Abstract of an illustrated talk before the Metropolitan section of the American Welding Company, April 17, 1921.

Reclamation Work on the Virginian

Knowledge of Effect of Heat on Material Is Essential for Proper Results in Reclaiming by Welding

BY F. S. TINDER
Material Inspector, Virginian Railway, Princeton, W. Va.

ALTHOUGH great progress has been made in reclaiming railroad material, reclamation is yet in its infancy. Reclaiming scrap and second-hand material by the use of autogenous welding is a scientific mechanical proposition and there is no longer any question of the results of this work from an efficient or economical standpoint where proper methods are used intelligently.

The man supervising reclamation work should have a knowledge of metals to be able to determine the physical condition of castings or forgings to be welded and what methods should be used. He should know the effect of various degrees of heat on the quality of different metals. He should also be acquainted with railroad equipment that he may know what stress and strains the parts must stand. In short, there is no department of railroad work where a knowledge of both theory and practice is more essential. The lack of appreciation of these facts has caused a large amount of inferior work to be done and the various methods of autogenous welding to be discredited.

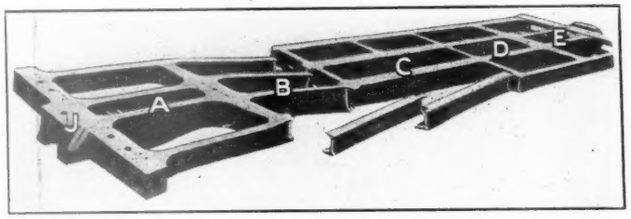


Fig. 1—Tender Frame of Mallet Locomotive as Received at Reclamation Yard

Restriction has been placed on welding certain parts for locomotives and cars by the American Railway Association; parts that could be successfully welded if the art of welding were generally understood. The importance of economy on railroads is now so great that railroad officers recognize the reclamation department as an important means to accomplish that end. This article is intended to tell of some of the work being done in the Virginian reclamation department at Princeton, W. Va.

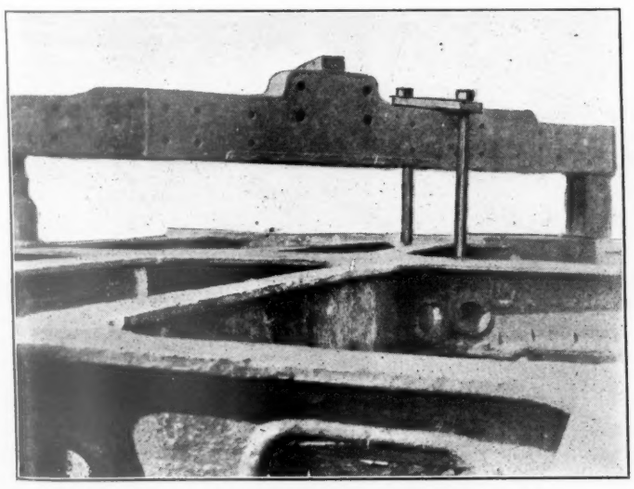


Fig. 2—Use of Cast Steel Bumper as Jacking Beam

Wrecked Cast Steel Tender Frame

Fig. 1 shows the frame of one of the Virginian's largest Mallet locomotives as it was received at the reclamation yard. In addition to being broken as shown, each section was badly twisted, varying with the top surface of the frame from 2 in. to 4½ in. Sections *A*, *C*, *D* and *E* were straightened separately, an old cast steel bumper sill being used as a jacking beam (Fig. 2). Longitudinal members were all heated at the twisted point with an oil burner and each section jacked straight and in line with the other. The ends of broken members in section *B* were heated and straightened by means of clamps and jacks. The end sill *J* was heated and drawn back in place in a similar manner. After all sections were straightened, each broken part was placed in line, leveled, and the parts to be welded prepared by cutting each side of the break to an angle of about 45 deg. with a cutting torch. The parts were preheated and kept hot with a charcoal fire while making welds. The two large center members were first welded, and to prevent stresses and strains being set up in any part of the frame, care was taken to have the proper amount of expansion in these two center members. Trams were used on each member before and after the welds were made and the amount of expansion and contraction carefully noted. This was so well taken care of that there was less than 3/32 in. variation in any part of the job. All welds were reheated and annealed after being completed on account of the size of the frame (8 ft. 6 in. wide by 36 ft. long, weight 10 tons). All welds were made by the oxy-acetylene process. Fig. 3 shows the frame completed. Following is an itemized list showing the actual cost to reclaim with the comparative cost of a new frame:

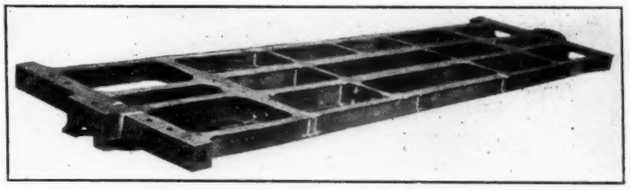


Fig. 3—Large Tender Frame as Reclaimed by Welding

Labor	$305.56
Oxweld welding rods	43.35
Charcoal	11.90
Headlight oil for heating	36.22
Oxygen	55.79
Acetylene	27.14
Total cost	$479.96
Estimated cost of new frame, including freight	$1,600.00
Cost to reclaim frame	479.96
Amount saved	$1,120.04

Reclaiming Car Couplers

Welding car couplers perhaps is the most important work being done at this plant from a standpoint of economy. The cost to weld couplers is not more than one-fifth of the cost

new. There are now about 3,000 welded couplers in service and the percentage of these that have failed on account of inferior welds is less than one per cent. Aside from trained welders, much of our success is due to heat treating. All couplers are preheated in an oil furnace, welded while hot, reheated to a cherry red and buried in dry sand to cool slowly. Fig. 4 shows a typical example of coupler reclamation. The record that has been made in this work on the Virginian is of special significance on account of the heavy trains handled. Car couplers with bent shanks and guard arms are reclaimed by heating in an oil furnace and straightened on an air press, which is a home-made machine and has a working pressure of about 50 tons. This machine is also used for straightening channel and angle iron, round and flat bar iron and various other distorted material of different kinds.

Miscellaneous Items

Locomotive piston bull rings are being reclaimed by building up worn parts, using Oxweld manganese bronze welding rods. This work results in a great saving, both in time and labor, as well as material. Various tests have been made which show that the bronze thus applied outlasts the original metal and also prolongs the life of the cylinders. There is no limit to the number of times pistons can be reclaimed in this manner.

Scrap rail frogs and switch points are being successfully reclaimed by building up worn parts with No. 2 Oxweld welding rods. When this metal is applied with a carbonizing flame properly controlled, it gives better service than the original metal. A number of these welded switch points and frogs are in use on the Virginian and are giving very satisfactory results.

Locomotive cylinders, throttle boxes and valves, air pump

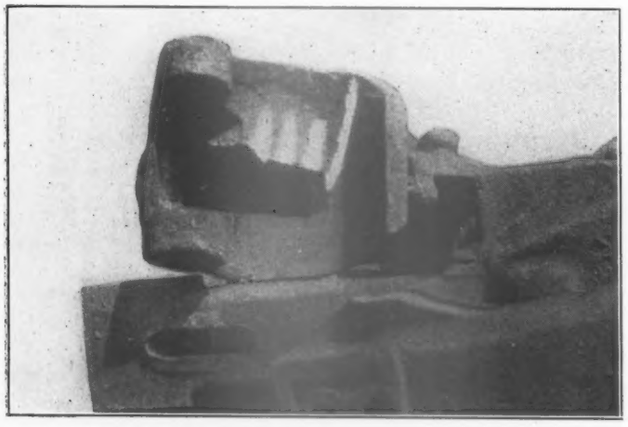


Fig. 4—Typical Example of Coupler Reclaimed by Welding

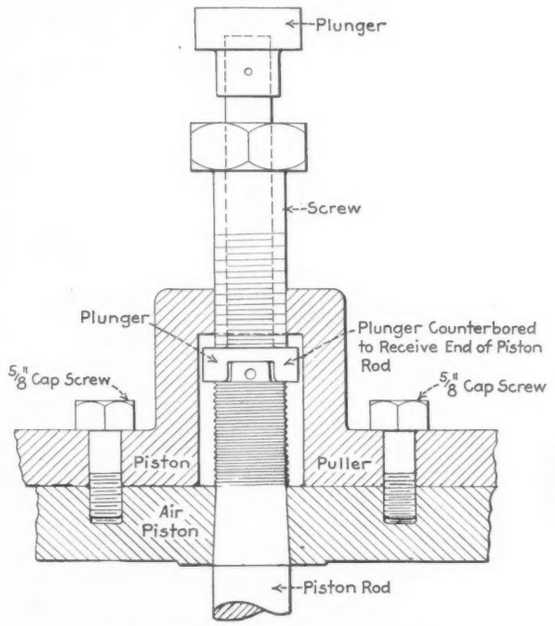
cylinders, brake cylinders and reservoirs, steam pipes, truck side frames, truck bolsters and other miscellaneous parts of locomotives and cars are being successfully repaired by the oxy-acetylene process.

There are many other things in process of reclamation at this plant which it is practically impossible to enumerate. Brake beams, brake rods and levers, globe and angle valves, maintenance of way tools such as tamping picks, clay picks, spike mauls, claw and lining bars are being repaired. Many odd jobs are brought to the reclamation plant that in themselves do not mean a great saving, but by being prepared to do such work immediately it is often possible to repair and return to service equipment which otherwise would be replaced only after a long delay. In addition to actual work, the general influence towards economy exercised by the reclamation department is of great value.

Device for Removing Air Compressor Pistons

BY J. H. HAHN
Assistant Machine Shop Foreman, Norfolk & Western, Portsmouth, Ohio

The illustration shows a useful device for removing air pistons from the rods of Westinghouse air compressors of all sizes. The strap is made of a piece of 2¼ in. stock shaped as indicated and drilled and tapped to receive the 1¼ in. hollow screw, which is threaded 10 threads to the inch. The strap is also counterbored to receive the plunger and piston rod end. The upper part of the plunger is



Westinghouse Air Compressor Piston Puller

detachable, being fixed in place by drilling and inserting a ⅛ in. pin as shown.

To remove a piston from the rod, the piston head remover is attached by the use of two ⅝ in. cap. screws in 11/16 in. holes. The screw is tightened down as much as possible with a wrench of proper length, using the customary method of preventing the piston and entire arrangement from turning when the screw is being tightened. After the screw has been tightened sufficiently, a light sledge hammer blow on the plunger will loosen the piston, when it can be removed from the rod. There is no damage to the end of the rods, as is the case when they are loosened by direct blows of a sledge hammer.

The illustration shows the piston head remover as it was used on a Westinghouse 8½ in. cross compound air pump. All pistons in the air ends of Westinghouse compressors, however, have been drilled and tapped to receive two ⅝ in. cap screws, 5½ in. on centers, so this device is readily applicable to all sizes of compressors.

CLASS I RAILROADS carried 2,249,567,625 tons of freight in 1920. Coal and other products of the mines accounted for more than 1,200,000,000 tons, or 53.6 per cent; grain and agricultural products 220,000,000 tons, or 9.78 per cent; lumber and forest products 197,000,000 tons, or 8.74 per cent; meat and animal products nearly 45,000,000 tons, or 1.99 per cent; manufactured and miscellaneous articles 21.91 per cent, or about 493,000,000 tons. The balance, some 90,000,000 tons, or 3.98 per cent, was the total of the "less-than-car-load" shipments.

Manufacturing Standard Locomotive Repair Parts

A Method of Standardizing and Manufacturing Locomotive Repair Parts in Central Production Shops

BY M. H. WILLIAMS

THE great importance of centralized production shops in manufacturing duplicate locomotive parts at reduced expense is becoming recognized more and more by forward looking railroad men. Not only is there a saving in the cost of manufacture, but both locomotives and cars are handled more promptly through shops and terminals due to the ready availability of semi-finished parts. This is the second installment of an article begun on page 451 of the July RAILWAY MECHANICAL ENGINEER, *describing the standardization and manufacture of locomotive parts. Taken in its entirety, the article is worthy of the most careful study.*

Standardized Thread Sizes

The products of the central production shop will naturally find their way into practically all shops and engine houses on the system and be made use of as occasion demands. As a result, a nut tapped today may be used on a crosshead or similar article that was made several months previously. Unless the nuts and threaded portions fit properly there is liable to be trouble and complaints, therefore interchangeability of threads is an important feature not only for the good of the road but also for the good name of the central production shop, and hence becomes a problem for this department to solve. Standard thread sizes and limits are now well established for the regular U. S. threads such as apply to the regular bolts and nuts for which standard and limit gages may be obtained to practically any degree of refinement desired.

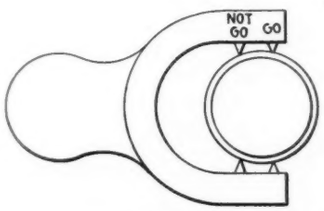


Fig. 8—A Point Thread Gage for Rapid Inspection

Various forms of threads are made use of such as the V, U. S. S., Whitworth, etc. It is not proposed to go into a discussion of the merits of each of these, but it may be said that the U. S. S. or U. S. F. is now becoming generally used for all locomotive work. The U. S. F. thread has the advantage that it can readily be cut by dies and measured by gages and thread micrometers and is therefore to be recommended for the articles made in central shops.

Various degrees of lost motion, or more properly speaking limits between the sizes of bolts and nuts have been recommended for threads used in the different trades. On account of rust and dirt which unavoidably accompanies locomotives it is not generally considered good practice to set these limits as close as is the common practice with machine tool builders or similar lines of product. Generally speaking for threads between ½ in. and 1½ in., if the bolt is between the theoretical size and 0.004 in. minus and the nut between theoretical size and 0.004 in. plus, all requirements will be met for the general run of work. The exception is in the case of boiler fittings where a steam tight joint is required. The two extremes mentioned if placed together will result in a loose nut. However, extremes rarely meet and to adopt the limits mentioned will be following a practice that has been well tried out for locomotive repair work and parts such as are generally made in central shops.

In order that there shall be no question as to the sizes for both the male and female threads, standards and limits should be determined to govern every thread that the central shop is called upon to produce. This in actual practice will be found comparatively simple. When the outside diameter is known it is only necessary to set the pitch diameter to agree with the outside diameter. Tables for the pitch diameter may be found in Brown & Sharpe and other catalogues giving all necessary information on this subject. As an illustration, reference to a catalogue shows that the pitch diameter for 12 thd. U. S. F. is 0.0541 in. smaller than the outside diameter; or a 1-in. staybolt with 12 threads per in. should have a pitch diameter 0.0541 in. less than 1 in. This equals 0.9459 in. or in round figures 0.946 in. Pitch diameters may readily be measured with standard thread micrometers.

On account of the large number of threaded parts that the central shop is called on to produce, it is necessary that gages used for inspection of these parts be simple in construction and require the minimum amount of time when testing each male or female thread. For quick inspection of the male thread it is doubtful whether any gage answers the requirements for minimum time and accuracy as well as the point gage shown in Fig. 8. This is a Go and NOT Go gage, the two front points being set to go over a thread that is not too large and the second pair not to go over a thread that is not too small. By the use of this simple gage the pieces may be inspected practically as fast as they can be picked up and laid down, with the result that a larger proportion of pieces will be tested than would be the case under conditions where a cumbersome or unhandy gage is used. For setting the two pairs of limiting points a master male gage is used, the work gages being frequently checked with these master gages.

For checking female threads, limit gages as shown in Fig. 9 are used. The smaller end that is marked Go should readily screw into the nuts and the opposite or larger end marked NOT Go should not turn into the nut. Where a large number of nuts are tapped with a single tap it is only necessary to test about one nut out of every 100. Where these two forms of gages are used a great improvement has always been noticed in the fitting of bolt and nut threads.

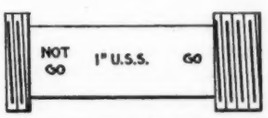


Fig. 9—Limit Female Thread Gage

Staybolts and Boiler Fittings

Staybolts, crown bolts and many fittings used on boilers can be manufactured cheaply in the central production shop for distribution to other points. In order that these parts shall fit properly it is essential that they be threaded to standard sizes subject to reasonable tolerances. Where this practice is followed and taps of correct diameters are used,

trouble and complaints from improper fitting will be reduced to a minimum.

In addition to possible errors that may exist in the articles manufactured in the central shop there is also the question of errors in the taps and wear of the same that must be considered. In other words, the standards and limits determined upon must include both the articles manufactured and the taps.

It was the practice a few years ago to make boiler threads of the sharp V form. However, it was found impossible to cut this form theoretically correct in every day shop practice and there was a lack of uniformity of sizes. One shop had one size, the next another and so on. On account of the difficulties encountered the U. S. F. thread is replacing the V form in a number of railway shops with a few places where the Whitworth form is preferred. All things considered, the U. S. F. is to be preferred especially by the central shop on account of being a well established thread which is easy to calculate and measure. The question of thread form may be somewhat foreign to the immediate subject and is mentioned to call attention to the necessity of establishing an easily measured and workable standard that should be used over the entire system.

Having determined upon the form, it is next necessary to set standards and limits for the pitch diameters of the threads. The maximum pitch diameter for U. S. F. should be the theoretical size for each nominal size of bolt as shown in Table I. The question of minimum size is open to argument. If this limit is too close the cost of threading will be excessive. If too much latitude is allowed, the bolts may fit more loosely in the boiler than is considered good practice. Experience has shown that if the minimum pitch diameter is 0.004 in. less than the maximum a happy medium will result and this is to be recommended for all radial staybolts, or all cases where the bolts are riveted or held by nuts. In some cases, as for instance the button ends of crown bolts, the threads are cut from theoretical size to plus 0.004 in. in order that they shall screw tightly and form a steam tight joint.

Table 1—Maximum and Minimum Pitch Diameters, 12 Threads, U. S. F.

Bolt Diameter	Maximum	Minimum
⅞ in.	.821 in.	.817 in.
15/16 in.	.883 in.	.879 in.
1 in.	.946 in.	.942 in.
1 1/16 in.	1.008 in.	1.004 in.
1 1/8 in.	1.071 in.	1.067 in.
1 3/16 in.	1.133 in.	1.129 in.
1 ¼ in.	1.196 in.	1.192 in.

In order to insure staybolts coming within the limits of thread sizes each operator of threading machines should be provided with limit gages as shown in Fig. 8 in order that the pitch diameter may be frequently tried. This threading should also be checked by inspectors by testing bolts selected at random. The results of this gaging and inspection will be that a high standard of uniformity will be maintained that insures the bolt coming close enough to a uniform size to fit properly in correctly tapped holes without adding to the cost of the threading operation.

While the question of staybolt taps may not come within the province of the central shop, it is a question that this department must keep an eye on in order that the staybolts and other articles supplied shall fit properly. Properly threaded bolts will not fit correctly unless the taps used for the boilers are of the right size. Generally speaking the manufacturers of staybolt taps maintain fairly close sizes and will supply to any degree of accuracy demanded. It is essential that the taps when new be somewhat larger than the theoretical diameter and in many cases they are made from 0.003 in. to 0.005 in. large in order that after tapping the sheets the bolt will readily enter and also to admit of a reasonable amount of wear. In order that the bolts shall not fit too tightly the taps should be discarded when worn down to the theoretical pitch diameter agreeing with the maximum size shown, Fig. 10.

While on the subject of thread sizes, mention will be made of thread micrometers, a necessary requisite of the central production shop and tool room. They should be provided in sizes required for all threaded articles to be manufactured. Without measuring devices of this nature is it difficult to measure or maintain sizes and set the gages to the limits required.

Grinding in Production Shops

Frequent reference has been made to grinding operations. As grinding machines have not been generally installed as a part of the central shop equipment, it may be permissible at this point to dwell on this subject. First considering plain cylindrical grinding, there are a number of surfaces on such articles as crosshead pins, crank pins, valve motion pins, etc., that should be finished to exact gage or micrometer sizes in the central shop owing to the economies that may be effected during quantity production. It has been amply proved that these surfaces can be machined in a more satisfactory manner, to closer limits and in less time by grinding than by any other known method. Another point worthy of consideration is that when blanking out articles they need not be kept to as close limits. As a result coarser feeds or cuts may be taken which increases the output of the automatic machines, turret lathes and other tools and also reduces the number of spoiled pieces.

A large amount of grinding on the parts mentioned is now done with broad faced wheels, as wide as the surface to be finished. When grinding, the wheel is fed directly onto the work without lateral motion. By this method the surfaces are ground to limits called for in from one to three minutes. It will readily be noted that this is much quicker than finishing by filing and emery papering. Longer surfaces must from necessity be ground by traversing the work back and forth in front of the wheel. In order to perform the grinding operations successfully and economically it is essential that large and rugged machines be provided. As a general rule these should not be smaller than the 10 in. by 36 in. size, heavy model.

Internal grinding where suitable machines are used has been found economical. However, in order to obtain the desired results it is necessary, as in the case of the cylindrical grinder, to make use of rugged machines which will remove metal quickly. Therefore the combination machine intended for external and internal use is of little value. The grinder should preferably be of the form known as the internal chucking grinder, having ample belt power and rigidity to drive the grinding wheel to its limit, and also arranged so that the work may be quickly placed in and removed from the chuck with all facilities for rapid handling and grinding. With a machine of this nature, the cost of finishing the bores of bushings is reduced to a point where the advantages of accuracy and interchangeability will much more than offset the extra time consumed by the grinding operation.

In order to obtain data as to the relative cost of finishing by grinding as compared with filing it will be found profitable to visit some of the outside shops that make extended use of grinding machines and compare the time taken in these places and in the home shops. A visit of this nature will generally reveal the fact that practically every cylindrical piece is finished on grinding machines owing partly to the close limits considered necessary and to the fact that grinding is the cheaper way to produce smooth and true surfaces. Much could be written on grinding operations in central production shops, but a visit of this nature will be more convincing than many books.

Reducing Maintenance Cost of Valve Chamber Bushings and Packing

BY FRANK ROBERTS

It has been the practice on an eastern road to bore steam chest bushings, when applied new, 12 in. on passenger and 14 in. on freight locomotives. After a time, service develops the usual wear, the bushings becoming out of round, scored, shouldered or otherwise defective, making reboring necessary. The practice is to keep both piston valves the same diameter. This makes it necessary to bore both sides whenever any

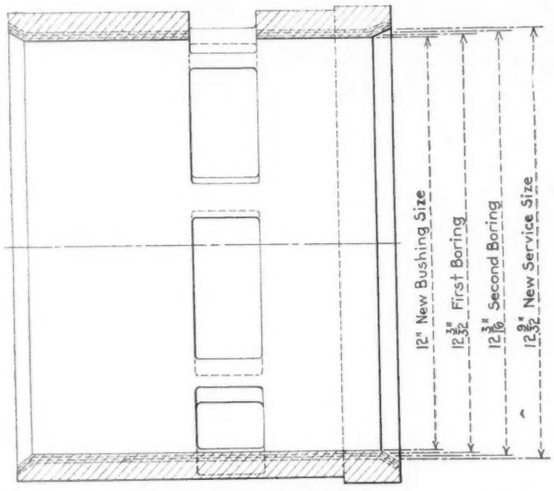


Fig. 1—An Additional Boring Is Obtained from this Bushing

one of the four bushings has a condition that will produce leakage past packing rings. The life of a steam chest bushing has previously been limited to three service periods, each being 3/32 in. above the last; first 12 in., second 12 3/32 in. and third 12 3/16 in. The packing rings were of necessity only good until bushings were rebored, when it became necessary to replace them with a new set 3/32 in. larger in diameter. The old ones were invariably scrapped.

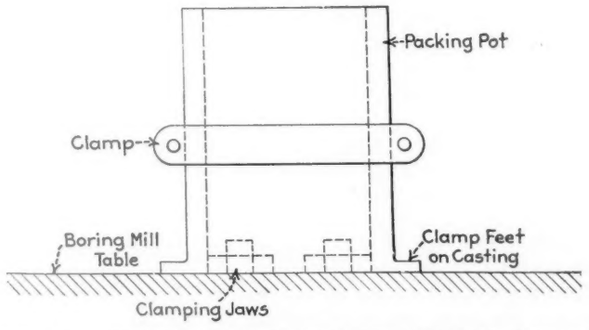


Fig. 2—Cut Packing Pot Closed by Boring Mill Table Jaws and Central Clamp

The present practice is to increase the life of bushings by one additional service period by boring the fourth time, scrapping bushings after they are 12 9/32 in. instead of 12 3/16 in. diameter as previously. The advantage as measured in miles and money is about as follows: From a mileage consideration, the bushings of passenger locomotives are bored nearly every time they come through the shops for general repairs. Freight locomotives average three times through the shop with two borings. For the present purpose it is assumed that bushings are bored twice every three times a locomotive passes through the shop. During the past year locomotives in for repairs have averaged 47,000 miles. On the basis of 4½ shoppings as constituting the previous life of a bushing, the bushing mileage would equal 211,500. Under the present system, using bushings with one more boring, would give 282,000 miles, an increase of 33 1/3 per cent. From a money consideration this works out equally advantageously. The mileage credit of the shop for 1920 was 10,427,604. Based on previous practice, the life of bushings was $\frac{10,427,604}{211,500}$ or 49.3 sets of bushings per year. On the present basis of four borings, it becomes $\frac{10,427,604}{282,000}$ or 36.98 sets of bushings per year, a saving of 12 sets, or practically 25 per cent. The cost of a set of bushings with three borings is $98.13, with four borings $108.33. On the above mileage basis, the yearly expense would be 50 multiplied by $98.13, or $4,906; for the second condition, 37 multiplied by $108.33 equals $4,008. The indicated saving is $898. This matter may be considered from another angle. There are roughly 225 locomotives that are using piston valve cages on this road. The previous system would call for $\frac{225}{4.5}$ or 50 sets, and the present method will require $\frac{225}{6}$ or 37 sets per year, if each locomotive comes into shop every 12 months, a saving of 13 sets, or practically 26 per cent. No matter how the question is considered, the advantage is between 25 and 30 per cent, or $100 per

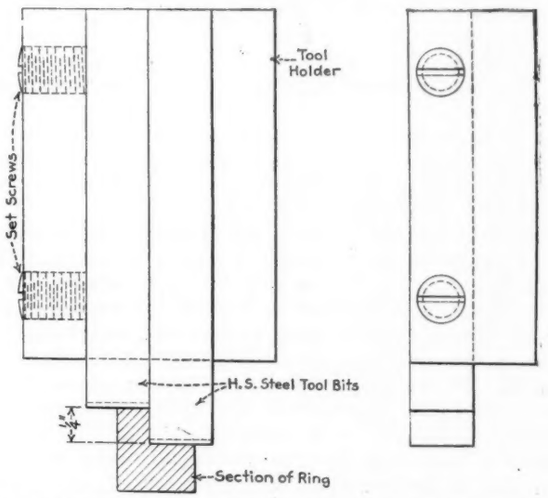


Fig. 3—Arrangement of Form Tool to Face the Top of the Packing Ring

month on a road using 225 piston valve locomotives. The cost of bushings is made up as follows:

4 bushings H. S. iron, weight 150 lb.	$41.60
Rough boring 8 hrs. at 85 cents	6.80
Turning and fitting, 8 hrs., at 85 cents	6.80
Milling slots, 6 hrs. at 85 cents	5.10
Pressing out old bushings, 2½ hrs. at 85 cents	2.13
Drawing in new bushings, 6 hrs. at 85 cents	5.10
Finishing boring bushings, 12 hrs. at 85 cents	10.20
Two service borings	20.40
	$98.13

A 12 in. bushing with the borings indicated is shown in Fig. 1.

A method has been developed for handling packing rings that has reduced the time and cost of machining the rings 50 per cent. This has come largely through the elimination of one turning, also through the use of a form tool that saves one cut and measurement. The previous method of machining these rings was to rough face them all over, cut out a portion of each ring to get the desired elasticity, close the ends together, and then turn and bore a second time to the finished size. The present practice is to cut out the proper amount of stock, usually ½ in. from the packing pot, clamping the casting to close the slot. The boring mill table jaws will clamp the lower end and a heavy

strap clamp in the center is necessary to close the top (Fig. 2). The upper half of the casting is bored and turned to the finished size and a special form tool used to face the top as shown in Fig. 3. Then with the micrometer adjustment the cut-off tool is set in the side post and the ring cut off. It is then complete and ready for assembly on the valve without further turning.

Another time-saving feature in this formed facing tool is that the head on the cross rail may be set to the correct diameter and clamped, no further measurements being required on following ring diameters. The facing tool is simply fed down to the proper depth on each subsequent ring. Casting blanks or packing pots 18 in. long are used, being held by a clamp for the first 10 in. and by the table jaws for the remainder. It is a saving to make a casting as long as a man can conveniently work over the top, and at the same time use a reasonable feed when cutting off rings. A casting

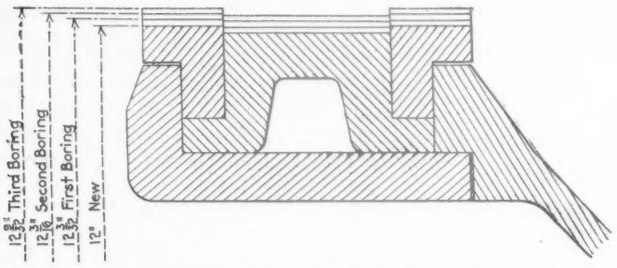


Fig. 4—Standardized Packing Ring with Four Step Sizes

can be made into 18, 14 in. finished rings in 8 hours, and this practice has reduced the time by about one-half largely through arousing the operator's full interest in a new machine and giving him adequate encouragement.

By standardizing packing ring diameters and having only one variable outside diameter, a second service is obtained from large discarded rings. It is simply necessary to turn down the outside diameter to the next smaller size. A new set of rings is applied nearly every time a locomotive passes through the shop, and many more are replaced in engine houses. On the basis of 200 locomotives using one new set per year, 1,600 rings will be used per year costing on an average $1.50 each, or $2,400 per year. Fig. 4 shows the standard ring with four sizes. If this item is followed and half of the rings pass through a second service period, it will save the cost of 800 rings, or $1,200 per year.

These matters are all worth giving attention, for they are the factors which in the aggregate distinguish efficient from wasteful and costly shop operation.

A System for Numbering Shop Machinery

BY J. P. SHAMBERGER

Several years' experience with the Interstate Commerce Commission, inspecting shop machinery and powerhouse equipment, has convinced me that the present system in use on the railroads for numbering machinery is capable of much improvement.

The usual method is to assign the number "1" to some machine at the main shop location, or the shop at one end of the line; then to number all machines consecutively, proceeding from shop building to shop building and from shop location to shop location. In the end, each machine has been given some particular number which performs only the simple primary function of serving as an identification mark. This system may be called good in that any system for numbering is better than none at all.

The system proposed here is known as the Dewey decimal system, used in practically every library in the country for indexing books. Its principal advantages when applied to shop machinery would be: First, the number itself would serve as a partial description of the machine. Second, the numerical arrangement of the cards bearing the machine numbers for any given shop, division, or system would place all machines of the same kind in one group.

The number to the left of the decimal point would represent the type of machine; the number to the right, the individual serial. The division into types may be carried out to an unlimited extent and the number may be made to show not only type, but also size. The type numbers might be as follows:

10 to 19 Lathes	50 to 59 Steam Pumps
20 to 29 Planers	60 to 69 Electric Generators
30 to 39 Shapers	70 to 79 Electric Motors
40 to 49 Steam Engines	

and the further division might be like this:

10. Engine Lathe	21. Wood Planer
11. Turret Lathe	30. Crank Shaper
12. Wheel Lathe	31. Wood Working Shaper,
13. Wood Lathe	etc.
20. Standard Metal Planer	

The engine lathe numbers would then be 10.1, 10.2, 10.3, and the numbers for all other machines would be similar.

The assigning of machine numbers should be done from a central office and the type numbers designated by some one familiar with the correct names for the different machines and there should be a print showing the proper place to stamp the number on each class of machines.

If it is worth while to stamp any number at all on a machine, it is certainly worth while to stamp one which will be of the greatest possible service.

A Few Points on Grinding*

BY CHARLES H. NORTON

Relatively hard wheels are used for soft material and for small work, and softer wheels for larger work and harder material. The reverse is true if one speed of work only is used and the same amount of material is removed in the same time.

The harder the material being ground the softer the wheel should be, or the faster the work surface, or both.

The softer the material being ground the harder the wheel should be, or the slower the work surface, or both.

The larger the work the softer the wheel should be, or the faster the work surface, or both.

The smaller the work the harder the wheel should be, or the slower the work surface, or both.

The larger the work the longer the arc of contact between work and wheel.

To counteract the effect of longer arc of contact the surface speed of the work must be increased. In fact the cutting action of the wheel can be controlled entirely by the work speeds.

The slower the work revolution and the softer the wheel, the deeper the cut may be, and with this combination a maximum amount of metal can be removed in a minimum time with a minimum loss of wheel and consumption of power.

Relatively fast work revolution with soft wheel causes the wheel to wear away rapidly.

The faster the work revolution the harder the wheel must be, whether roughing or finishing.

Slow work revolution, hard wheel, and deep cut cause the wheel face to load with steel, preventing the wheel cutting.

The slower the work revolution the softer the wheel must be, whether roughing or finishing.

Slow work revolution, and hard wheel with light cut cause the wheel to glaze, preventing the wheel from cutting.

By the use of the variable work speeds of grinding machines, it is possible to use on small, hard material the wheels graded for large, soft material and vice versa.

*Abstracted from Grits and Grinds, 1921. Copyright by Norton Company, Worcester, Mass.

Floodlighting for the Turntable and Lead Tracks. Photograph by the American Lighting Company, Chicago

Electric Power and Light for Railroad Shops*

The Trend of Development and Standards Adopted in the Power and Lighting Field

BY J. E. GARDNER
Electrical Engineer, Chicago, Burlington & Quincy

THE Electrical Department of a steam railroad has a varied field in which to work, comprising the mechanical department, the building department, the water service department, in fact, the whole engineering department, and it handles both power and lighting installations as well as welding and electric furnace installations.

Electricity is being adopted as the form of energy for various uses, because it means, in practically every case of its use, a direct economy to the railroad, and this question of economy of operation must be considered in planning any new installation. In most cases, this can be calculated in actual dollars and cents. The reliability of electrical operation is an important factor and it is the aim of the electrical department to make reliability and dependability its first consideration in laying out an installation, including due observance of "safety first" measures.

The rapid growth of the electrical industry may be seen from the fact that in 1915 the motors in the United States served by central station power amounted to a total of 6,100,000 horsepower, whereas in 1920 they totaled over 12,900,000, an increase of over 100 per cent in five years. Similarly, the number of incandescent lamps sold per year increased from 4,000,000 in 1890 to 110,000,000 in 1915 and 231,000,000 in 1920, also an increase of over 100 per cent in the last five years.

Alternating Current vs. Direct Current Power

One of the very first considerations in a power installation is the proper type of power to adopt. If power is to be purchased, it will nearly always be found that the power company can supply three-phase alternating current, and can supply this at a cheaper rate than the direct current in cases where it can furnish either. In cases where power is to be generated, three-phase alternating current is fast becoming the current adopted, and for very good reasons.

For transmission purposes, three-phase power is unquestionably the preferable type, as the use of transformers gives the choice of all voltages for any one installation and allows the same power to be efficiently converted to 110 volts for lighting purposes.

The three-phase motor, especially the squirrel cage type, has many advantages over the direct current motor wherever a constant speed motor can be used. It has no commutator to give trouble, and in the case of the squirrel cage motor it has no moving electrical contacts or brushes whatever, and no rubbing parts except the bearings. The manufacturers have now developed rotors to squirrel cage motors that are almost indestructible, and so long as the bearings are kept properly lubricated and the motor is not improperly overloaded it will run indefinitely without giving trouble.

The control of a squirrel cage motor is of the simplest possible type to operate. The starting of such a motor by hand control consists, in the case of the smaller motors, merely of throwing in a switch, and in the case of the larger motors, of throwing the double throw switch of a compensator. The stopping of such a motor consists merely in the throwing out of the switch, either directly or by means of a push-button. Further, this push-button, or in fact a series of push-buttons, can be located at convenient points for stopping the motor either for its regular operation or in emergency. In short, the squirrel cage motor is the most rugged and fool proof motor obtainable, and should be used wherever possible. It has, however, the characteristic of lower starting torque than can be obtained from the slip ring motor, which makes the slip ring motor necessary for starting machinery that must start under heavy load, as air compressors, triplex pumps, etc.

The direct current motor has to its credit the variable, or adjustable, speed that can be obtained from it and is used wherever possible, when this quality is of prime importance. For this reason, many large shops furnish both three-phase and direct current, using the direct current where adjustable speed is needed. However, even in such cases the ordinary procedure is to generate three-phase current first and convert this to direct current by a motor generator set or a rotary con-

*Abstract of a paper presented before the Western Railway Club, March 21, 1921.

verter, so that the direct current immediately becomes more expensive to generate, due to the losses in this apparatus.

Furthermore, alternating current is coming to such universal use that many manufacturers are furnishing sufficient speed changes in their standard machine tools to permit the use of a constant speed motor. In very many cases it is cheaper to purchase a tool with sufficient speed changes to permit the use of a squirrel cage motor than to purchase a tool without such changes, but with an adjustable speed direct-current motor.

For traveling crane drive, the direct current series motors have the advantage that their light load speed is much faster than their full load speed, which makes the operation of the crane faster when handling light loads or running light.

The use of synchronous motors is to be considered in the case of large motors which run practically all of the time under fairly steady load, as for instance the motors of motor generator sets or motor driven air compressors. This is especially desirable where alternating current is generated at the shop or where the power company furnishing current demands a penalty for low power factor. The use of such a synchronous motor in a power plant will raise the power factor of the plant instead of lowering it, as is often the case when such apparatus is driven by large induction motors. In cases where the alternating current generating equipment has become overloaded it should be investigated to see if the use of a synchronous motor will not overcome the trouble before recommending additional generators.

Individual vs. Group Drive

In the days when the machinery in the shop was driven by steam power, the usual procedure was to have one large engine drive all of the machinery in one shop. When these engines began to be superseded by electric motors it was found to be of considerable advantage to divide the shop into various groups handled by separate motors, and in the case of certain machines to drive them by individual motors. In this way it was possible to eliminate a great deal of the friction caused by the large amount of shafting, belts, etc., in the shop, and also to operate part of the shop without the necessity of running all of the shafting. The growing use of traveling cranes for machine shops has aided to develop the use of individual motor drive for machine tools, as this does away with all of the shop shafting. Individual drive also gives the added advantage that the tool can be quickly located in any position in the shop. However, in shops, or in shop bays, not equipped with traveling cranes, and especially for the smaller tools, the advantage of individual drive is in many cases neutralized by the added cost of the necessary motors for such drives.

The horsepower of the motors in a shop equipped with individual drive would be much more than in a shop equipped with group drive, and the cost of the motor installation will show a much greater contrast owing to the fact that the smaller motors cost more per horsepower than the larger motors. In the smaller railroad repair shops especiat the same time. If individual drive is adopted, each motor must be large enough to handle the maximum load on that machine tool, and in the case of reciprocating machines, as planers, slotters, etc., the motor must be large enough or the machine must be equipped with enough flywheel capacity to furnish the momentary energy required to reverse the machine at the end of the stroke. In the case of group drive, all of the energy stored in the shafting and various machines of the shop is available at such an instant, and this fact makes a still greater difference in the horsepower required with the group drive as compared to that with the individual drive.

Furthermore, with a shop using only alternating current a few motors loaded nearly to capacity will furnish a much higher power factor than a large number of motors carrying light loads. This is of special importance if the shop generates its own electric power.

Consequently, before deciding to adopt individual drive throughout an entire shop, it must be carefully considered as to whether the additional cost is warranted, as compared with group drive, especially for the smaller machines.

In laying out group drive for a shop, such as is found at a roundhouse point, it is advisable to put certain tools that are likely to be used at any time for emergency work in a group by themselves so as not to necessitate running of a large number of tools during the night.

Standardization of Motor Speeds and Voltages

The size and first cost of a motor decrease as the speed increases, consequently in designing a motor drive care should be taken to see that a motor of the highest practical speed is used. For gearing or chain drive, the speed of the motor must be selected with care not to exceed speeds in good practice, taking into consideration the size of the motor. For belt drive, the size of the two pulleys and the reduction of speed permissible with one pair of pulleys determines the motor speed that must not be exceeded. For 60-cycle, three-phase motors the speeds most commonly used are no load speeds of 1,800, 1,200, 900 and 720 r.p.m., with full load speeds approximately 5 per cent less, and a safe plan to follow for a belted motor is to see if a 1,200 r.p.m. speed can be used and work as near to this speed as possible without getting too great a pulley ratio.

Basing the price of 1,200 r.p.m. motor at $100 for the sake of convenience, the relative price of motors of the various speeds is approximately as follows:

Speed in RPM.	Comparative cost
1,800	$77
1,200	100
900	125
720	142
600	158

In order to standardize on motor speeds, the manufacturers are furnishing direct current motors with approximately the same speeds as the full load speeds of alternating current motors. It is also, of course, a decided advantage to the motor user to keep the motor speeds as near standard as possible, and this should be considered in selecting motors.

The advantage of a spare motor, and the ease with which motors can be transferred from one tool to another in a shop is increased to the extent that such standardization is perfected. Another argument in favor of motors of speeds of 1,200 or 900 r.p.m. is that they can be more readily purchased.

Voltages should also be standardized as far as possible for the various shops on one railroad. For direct current, 230 volts is beyond doubt the best for power. For three-phase current, 220- and 440-volt motors are both used, and the majority of the induction motors manufactured can be reconnected for either voltage. For a good-sized shop the cost of copper wire for power circuits is a large item, and if 440 volts is used instead of 220, the circuit wires will be half the size, and feeders, when the voltage drop determines the size, can be one-fourth the size. For this reason 440 volts is recommended for a standard.

When a fuse blows, the motor is shut down until the fuse is replaced, a condition which means a delay, and in many cases a serious delay. When a circuit breaker throws out it is only a matter of seconds for the operator to throw it in again and have the motor running. For this reason, circuit breakers or overload relays are recommended for use on every electric motor and are well worth the additional cost in time saved. For induction motors overload relays will be used in connection with the compensator, oil switch, or other starting device.

The "safety first" campaign in all industrial lines has

been the means of bringing out many new types of safety switches and safety devices, most of which are commendable. Safety switches mean protection against personal injury, against fire and against power failures. In addition to the safety switches, many panel boards now have the fuses of each polarity or phase in a separate compartment, the different compartments being separated by barriers. Compensators can now be obtained with the relays and no-voltage coil complete inside of the same case as the compensator, which adds to the convenience and neatness of wiring. Automatic starters can be purchased complete with enclosing cabinets so that they can be located close to the motor without need of additional protection, and so that a complete conduit installation can be made.

Pumping Plant Operation

The present high price of labor, gasoline, kerosene and coal combine to make electrical operation economical in many pumping plants and coaling stations where electric power is available. In many cases the use of automatic control is the determining factor in reducing the cost of labor for operating a pumping plant. However, no automatic devices are absolutely infallible, and where hand starting can be operated without great additional expense it is advisable, as it makes it necessary that the attendant visit the plant at least once every time the motor is started. Pumps do not always prime properly, pumps and motors have to be oiled at regular intervals, bearings run hot occasionally, so that it is not fair to any equipment, however reliable, to expect it to operate day in and day out without attention.

In the case of the most important water stations, duplicate equipment is recommended for protection in emergency, and where such stations are operated by automatic control, a hand controller is recommended in addition to the automatic controller, this being so connected that reversing a double-throw switch cuts the motor control on either the hand controller or the automatic starter, and disconnects the other entirely so that it can be taken out for repairs without shutting down the plant. The writer has installed this equipment in three important pumping stations, and its value in time of emergency has been well proved.

Automatic Control for Shop Motors

Automatic control is slowly being introduced into the railroad machine shops for controlling certain machine tool motors. The arguments in favor of automatic control are that it enables any operator to start the motor properly, that the motor control may be placed where most convenient to the operator, and that with direct current motors dynamic braking may be used to stop the motor almost instantaneously when necessary.

In the case of direct current wheel lathe motors, an added argument is that the motor may be momentarily slowed down by the push-button control at times when the tool strikes a hard spot on the tire.

The reversing planer motor is a recent adaptation of automatic control, which is successfully used to speed up the operation of planers both for large and small work. For this equipment, a special motor is used that will stand starting, stopping and reversing at each stroke of the planer. With this control a great time saving is made by the readiness with which the cutting speed or the return speed may be regulated, each independently of the other by elimination of belt slip and by the quickness with which the operator can start or stop the motor either in the regular course of its duties or while setting up work.

Elevator Control

Automatic control is now being successfully used to operate both passenger and freight elevators. One serious disadvantage in the use of automatic control for freight elevators has been that if the car was adjusted to stop at the floor level when carrying a heavy load, it would not stop at the floor level when carrying a light load, making it hard to handle trucks in and out of the elevator. Elevator equipment can now be obtained, however, having a small motor driving the armature of the main elevator motor at slow speed through additional gearing, and by using special leveling cams at each floor level so that when the car reaches the floor at which it is to stop the main elevator motor stops and the small leveling motor then picks up the control, brings the car absolutely to the floor level, and holds it there. With the present high price of labor, such a device often means considerable saving.

Interior Lighting

The rapid development of incandescent lamps within the last few years has added entirely new possibilities in the electric lighting field, and the intensity of illumination which is recommended to be supplied has increased year by year. From a railroad point of view, we see in this two separate phases. First, utility lighting in shops, roundhouses, offices, yards, etc., where the lighting is for the advantage of the railroad employees. Second, lighting that must have a certain decorative value, as railroad trains, stations, and such places where the lighting is for the benefit of railroad patrons as well as railroad employees. A study of the situation shows that in practically every case the amount of light furnished is much greater than it was a few years ago. In the case of shop lighting, yard lighting, etc., it has been proved that by furnishing general illumination of sufficient intensity, the efficiency of the workmen is greatly increased as well as the quality of the output and the protection against accidents.

Until recently it has been the custom to employ mechanics for night work at roundhouses, etc., and expect them to do good work with the light of an oil torch. The recent increased cost of labor brought out the fact faster than it would otherwise have been brought out that it is absolute economy to furnish proper lighting at such points, especially where work is being done all night long. The cost of electric lighting is a small item compared to the total cost of operating a shop, so that the question must be carefully considered at each shop as to whether sufficient illumination is provided. A record of eight years ago shows that as low as two foot-candles was recommended at that time for machine shop lighting, whereas the latest recommendations are from five to ten foot-candles. By furnishing general illumination of sufficient intensity the use of portable cords can largely be done away with. A portable cord has always been an expense to maintain, and the small lamp used with the portable cord, as well as the lamps used for drop lights, have always been a source of expense due to breakage and theft. By lighting the shop with large lamps located in suitable reflectors at a considerable height above the floor, trouble due to lamp breakage, theft and lamp cord maintenance is done away with, and at the same time much better lighting is obtained.

The only recent important addition to the available lamps is the bowl enameled gas filled lamp. This lamp is designed for use in the standard reflectors, the enameling being to dispense with the glare caused by a bare gas filled lamp when placed low enough to be in the line of vision.

Yard Lighting

The use of large Mazda lamps has made possible lighting of large outdoor areas by the use of flood lights. A few years ago the method of lighting a hump yard, or in fact any freight yard, was to install rows of arc lights between the tracks or suspended over the tracks. At a later date the Mazda lamp superseded the arc lamp, still using the large number of lamps distributed through the yard. Now, by the use of a few flood lights located at proper points, much

better illumination can be obtained and the cost of maintenance reduced. For a hump yard, a flood lighting tower located at the top of the hump will enable the car riders to see ahead of them almost as distinctly at night as in the daytime, and thus permit them to carry their cars as far from the hump as possible and yet avoid damage to the cars or contents.

For best results, these flood lights should be located not less than 50 ft. from the ground, and preferably, at least 75 ft. For lighting the larger areas, 1,000-watt lamps should be used, and the reflectors of the flood lights should be of mirrored glass or metal that will not easily tarnish. This latter is a point that must be carefully considered, as the average flood light does not get the attention that a locomotive headlight reflector receives. In cases where one 1,000-watt lamp is not enough to light a given area, the usual practice is to install a battery of several of these lamps. By slight changes in the focusing and position of the different reflectors, the light can be distributed over the proper area. The use of flood lights has the decided advantage of leaving the space to be lighted largely free from poles and overhead wires. In the case of a cinder pit, especially where the cinders are handled by a clam shell, the lighting has always been difficult and hard to maintain. The use of flood lights placed at proper points at the end of the cinder pit will improve this condition wonderfully.

One point that must be carefully noted in laying out a flood light installation is that the flood light should be placed, as far as possible, so that it will throw its light parallel to the tracks. If the flood light is placed so that it has to throw its light at right angles to the tracks, any cars or locomotives standing on the tracks will throw dark shadows at the very place it is desired to light.

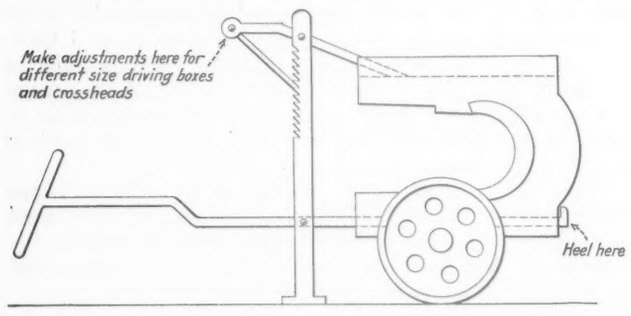
Flood lighting is well adapted for the purpose of lighting long freight or passenger platforms where these are not covered by canopies, but if not located at a sufficient elevation they will cast a disagreeable glare.

Truck for Driving Boxes

BY J. H. HAHN

Assistant Machine Shop Foreman, Norfolk & Western, Portsmouth, Ohio.

A shop truck designed especially for hauling driving boxes but which can also be used in moving crossheads from place to place is shown in the illustration. No dimensions are furnished with this sketch owing to the fact that the truck will



Shop and Roundhouse Truck for Handling Driving Boxes

have to be designed to accommodate the driving boxes and crossheads on the particular road for which it is made. The principle of operation of the truck is evident, however, and heavy driving boxes and crossheads can be moved from one machine to another and from one department to another with a minimum of physical effort.

A pair of comparatively large diameter wheels are mounted on an axle attached to a plate which fits in the shoe and wedge way and has a heel on one end to hook under the box. On the handle side of the truck is a swinging arm to which is attached a lever and notch arrangement for holding the box in place when tipping up the truck.

In operation the driving box is turned upside down on the floor and the truck brought into position with the heel tipped down and under the driving box. The box is then clamped in place with the arrangement shown and a downward pressure on the handle of the truck will then lift the driving box off the floor. The design of the truck is such that the center of gravity with the driving box in place lies approximately over the axle so it is easy to handle the truck and move it from place to place. Adjustments are made for different sizes of driving boxes by means of the clamping arrangement shown. An extension to the swinging arm serves to support the truck and box in a horizontal position when desired.

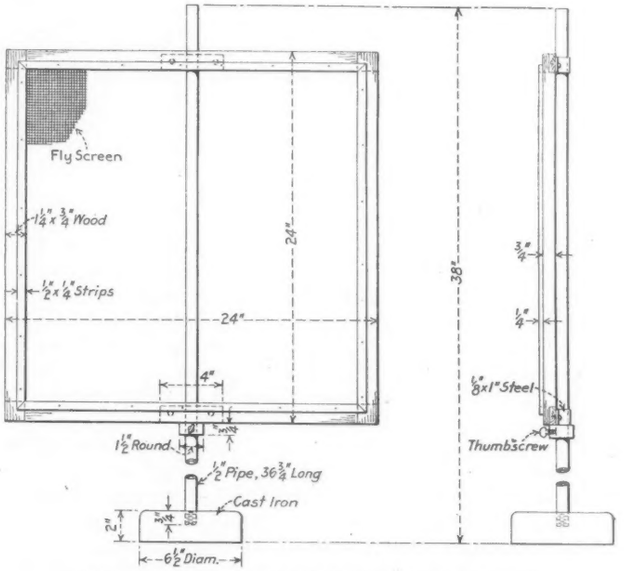
With this device, driving boxes and crossheads have to be lifted only a short distance from the floor and they can be moved from one part of the shop to another with a minimum of effort.

An Improved Chipping Screen

BY A. G. JOHNSON

Mechanical Engineer, Duluth & Iron Range, Two Harbors, Minn.

The well-organized movement to reduce accidents by safety first campaigns has accomplished desirable results. One of the points most strongly insisted upon has been the provision of suitable means to prevent accidents by flying chips. The chipping screen illustrated was designed for this purpose and is convenient, being readily adjustable in position and elevation on the work bench. As illustrated, the



Convenient Type of Adjustable Chipping Screen

screen consists of a wooden framework made from 1¼ in. by ¾ in. stock. Strips, ½ in. by ¼ in., are provided to hold the fly screen in place on the framework and the latter is arranged to swivel on a piece of ½ in. pipe threaded into a cast iron base sufficiently heavy to hold the screen in an upright position. The collar and set screw, indicated, provide for easy adjustment of the screen vertically.

A screen of this general type may be arranged with two or more hinged wings which can be set or clamped at any angle for use around a boring mill when turning brass. This confines the chips to a small floor area and helps to save the scrap brass. When not in use, the wings can be shut and set against the wall out of the way.

Locomotive Main Rod Angularity

BY WILLIAM ULRICH

Foreman Valve Setter, Delaware, Lackawanna & Western, Scranton, Pa.

There has been considerable discussion of the subject of irregularity in valve motion due to locomotive main rod angularity and other errors which must be overcome to obtain a square valve gear. Main rod angularity and the difference in elevation of cylinder and driving wheel center lines have introduced errors which must be overcome and this article is

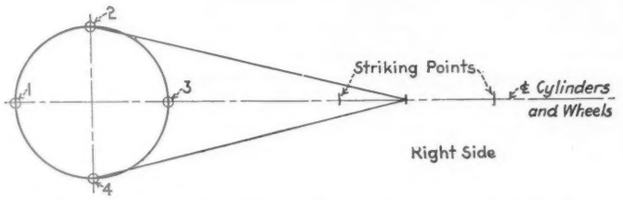


Fig. 1—Crank Pin Positions When Center Lines Coincide

intended to show the effect of these two errors; how one overcomes the other on one side of the locomotive and increases the error on the other side; how the roll of the engine, which cannot be fully counteracted, constantly changes these errors. It is hoped to give the practical valve setter a clearer idea of the subject under discussion and point out the advantage of working from the front centers in setting valves. Too frequently the assumption is made that the largest errors in valve motion are due to main rod angularity when the trouble due to other causes is far more serious. In reality, the errors due to main rod angularity have little effect upon the valves.

With locomotives of today, having long main driving rods, angularity has much less effect than when main rods are

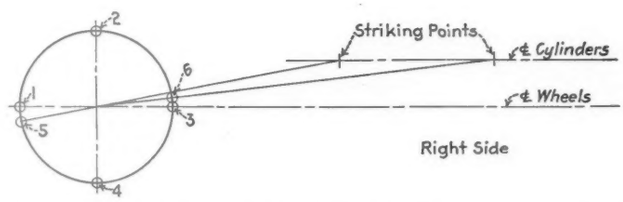


Fig. 2—Diagram Showing Effect of Raising Cylinder Center Line

short, as in the case of locomotives of older design. Angularity is less, on account of the longer radius, although this decrease is slightly offset by the longer stroke of modern locomotives. The effect of relative main rod length and piston stroke will be readily understood from reference to Fig. 1, which shows four crank pin positions corresponding to the two dead centers and the top and bottom quarters.

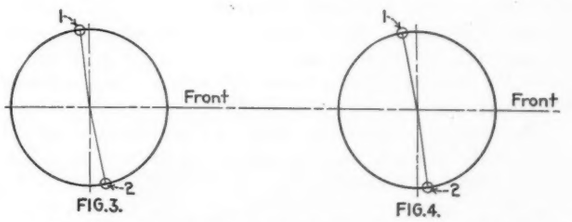
Dead Centers Not Diametrically Opposite

The cylinder center lines on nearly all locomotives are from 1 in. to 3 in. higher than the center lines of the wheels, thus bringing the dead centers not diametrically opposite. By studying Fig. 2, it will be evident that a slight error exists. The rear dead center is at *5* and the front dead center at *6*. If the cylinder center line was at the same elevation as the center line of the driving wheels, as shown in Fig. 1, arc *1-2-3* would be equal to arc *1-4-3* and the dead centers would be opposite each other. In Fig. 2, arc *5-1-2-6* is slightly longer than arc *6-3-4-5*, the difference being an error due to the difference in elevation of the center lines.

For convenience, it will be considered that Fig. 2 represents the right side of the locomotive. With the locomotive on the front dead center (right lead engine), the left crank pin would be in position *1*, Fig. 3, or if on the back center, position *2*, Fig. 3. The greater the difference in cylinder and driving wheel center line elevation, the greater will be this error. The error is practically negligible for differences in center line elevation not exceeding 3 in. and it is impossible to figure it exactly as valve setting in the back shop is generally done while the locomotive is being assembled. When the boiler is filled with water and the locomotive settles on its springs, the center lines of wheels and cylinders come closer together, and when the locomotive is working, the roll constantly changes this distance. In setting valves, it is good policy to work from the front centers as much as possible since they are near the center line of motion.

The position of the right crank pin when the left pin is on either front or back center, is shown in Fig. 4. When the left crank pin is on the front center, the right pin will be 90 deg. ahead, or at position *2*, and when on the back center, position *1*, Fig. 4. This shows that the error due to the dead centers not being diametrically opposite helps offset the error due to main road angularity on the left side and increases the error on the right side.

The position of the left crank pin with the right pin on either front or back center is shown in Fig. 5. If the piston was at the center of the stroke, the main pin would have to be on points A or A_1. It will be noted that when the right crank pin is on the front dead center, the left pin would have to be at point A to bring the piston to the center of its stroke. In reality the left crank pin is at B and there is an error equal



Figs. 3 and 4—Left and Right Crank Pin Positions with Opposite Crank Pins on Dead Centers

to the distance between points A and B. When the right crank pin is on the back dead center, the left pin would be at point A_1 where it is (in this case) due to the fact that the two center lines do not coincide. If they were in the same line, an error would exist equally on the front and back centers. On the right side the longer arc between points *1* and *2* (Fig. 4) is toward the front and the offset from the center point of the stroke is increased. This error will be about 5/8 in. It will be more with a shorter main rod and

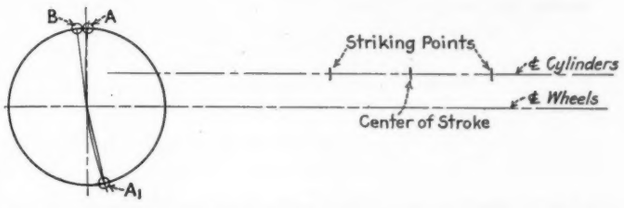


Fig. 5—Diagram Showing How Error Due to Angularity is Increased on Right and Decreased on Left Side

less with a longer main rod, and it will also be more with a longer stroke and less with a shorter one.

Methods of Counteracting Errors

The above irregularities are overcome in the Stephenson valve gear, however, by offsetting the link saddle, although this feature of design must take care of other errors, such as those due to eccentric blade angularity, and the location of the eccentric blade pins back of the link arc. In the Walschaert gear, irregularities are overcome by the back set of

the link foot, which also takes care of the angularity of the eccentric rod.

These errors are greater at 50 per cent cut-off than they are on a shorter or longer cut-off, as when the crank pin is nearer the centers (either front or back), the piston is not traveling as fast as when it is on the top or bottom quarter. In other words, the wheel must revolve farther with the crank pin near the dead centers to move the piston a certain distance than if the pin was on the top or bottom quarter.

Increasing the Efficiency of Piston Rod and Throttle Packing

BY FRANK ROBERTS

The writer has made many comparative tests on both air pump piston rod, and throttle valve stem packings. Among the packings tested are included both metallic and the usual fibre braided packings, varying in price from a few cents to over two dollars a pound. The conclusions deduced below are the direct result of this service test study.

It is evident to any railroad man who has spent much time around an enginehouse, that the majority of packing is removed from service, not because it is worn out, but because it leaks steam and is no longer serviceable. What usually causes removal under the action of service conditions in stuffing boxes, is not an appreciable wear, but the loss of elasticity. The heat and pressure dries and hardens the plastic fibre rings until they are absolutely non-resilient. No amount of pressure applied at packing gland nuts will cause the rings to close around the rod or stem sufficiently to hold back the escaping steam.

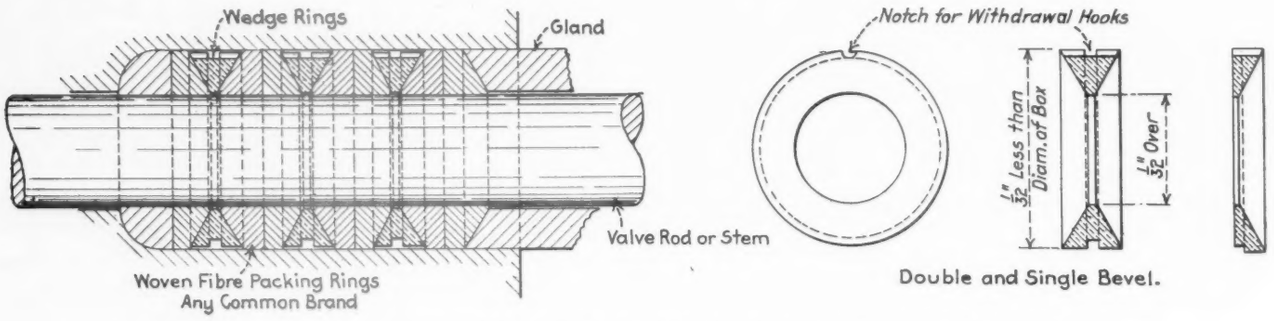
The engineer reports packing blowing and the repair man removes the old and applies a new set of packing. A casual glance about any enginehouse scrap box or yard will show how many apparently perfect rings are thrown away. Examination will show that these discarded rings are as hard as bone but the inside wearing surface is polished and perfect. All it requires is a means of pressing it close against the rod to seal the joint and hold back the steam. With proper compression there is no reason why rings will not give good service for a period at least double that now obtained.

The use of wedge rings, shown in the illustration, will effectively compress packing rings long after they have lost their resilient properties. Even after they become quite hard a moderate pressure from the gland nut, operating through the bevelled dividing faces, causes a wedging action that forces the packing rings against the rod, effectively compressing the rings long after they have lost their resilient properties. This wedging action forces the packing rings against the rod, effectively preventing the escape of steam. Our finding is that the life of rings is increased over 100 per cent.

Another decided advantage resulting from doubling the life of a set of throttle packing is the money and time saved by not having to blow down the boiler so often for changing the throttle packing. This is an expense which is not incurred, however, when changing a set of air pump rod packing.

The item of lubrication is perhaps a leading factor in satisfactory packing service. The pumps are not so hard to lubricate if proper swab rings are applied, and supplied with oil, but the throttle stem is a different problem. A deep packing box, several times exceeding the total travel of the stem is used, and any oil applied to the stem outside of the packing box gland is carried only a little way into packing box, reaching only the first rings. The rings next the steam never get any of the oil, and soon dry out hard, losing their ability to hold back steam.

The cost of wedge rings is of no special moment, in fact less than the cost of the fibre rings displaced during the first application. They may be used repeatedly if made of brass and can be easily cast, thus eliminating all machine work and bringing the price down to a few cents each. The rings will save time, trouble, and expense.



Wedge Rings Hold Old Packing Tightly Against Valve Stem, Preventing Leaks

The Use of Hack Saw Blades*

It is better to err in using a hack saw machine blade a few gages too heavy rather than one gage too light, as this practice will result in much less breakage.

Never use a coarse tooth blade on thin sheet metal or tubing of any kind as the teeth are bound to strip or the blade become broken.

For cutting solid material of all kinds, 14- and 18-point blades may be used to good advantage.

Where gages from 16 to 21 are being cut (either tubing or sheet metal) a 24-point blade will give best results.

When cutting material finer than 21 gage in any metal, a 32-point blade will give best results.

Extreme care must be used in weighting a blade when cutting unannealed tool steel as too much weight on a new blade will ruin it quickly.

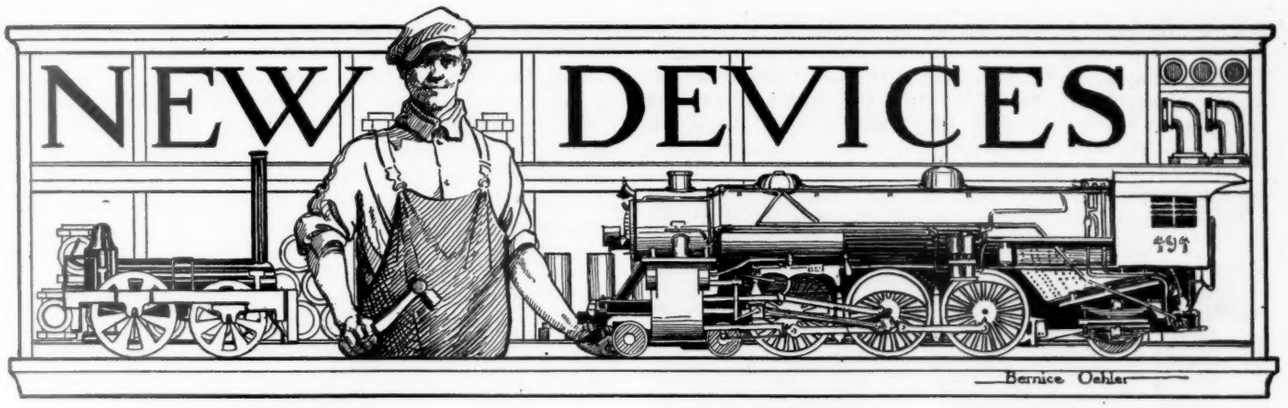
Never buy a cheap hack saw blade as the cheapest is usually most expensive in the end.

Experience has proved that 90 per cent of hack saw troubles are caused by using blades on work for which they were never intended.

If in doubt as to the kind of blade to order, ask the manufacturer and he should be able to give you assistance.

WHAT IS PROBABLY the greatest "layoff" which ever occurred in the transportation industry took place between August, 1920, and March, 1921, when, according to the statistics of the Interstate Commerce Commission, the total number of employees on the Class I railroads decreased from 2,197,824 in August, 1920, to 1,593,068 in March, 1921, representing a decrease of 604,756, or 27.5 per cent.

*From a circular issued by the Diamond Saw & Stamping Works, Buffalo, N. Y.

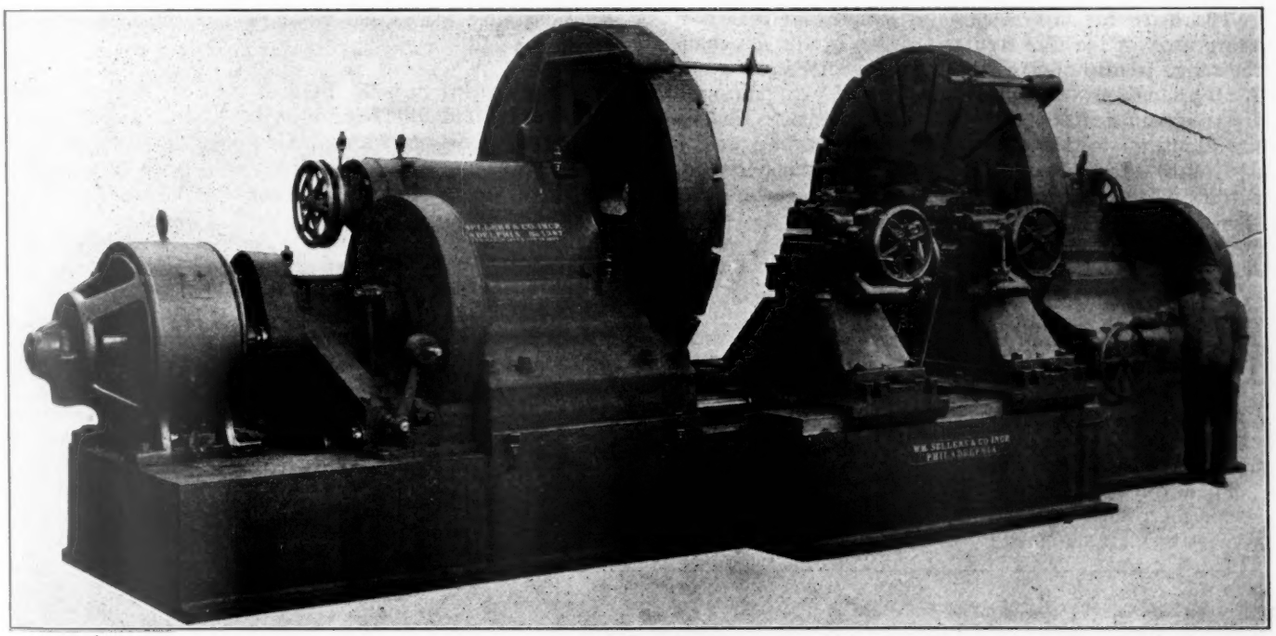


Heavy Pattern 90-In. Driving Wheel Lathe

MODERN facilities for wheel turning, quartering and journal turning are combined in the heavy pattern 90-in. wheel lathe, illustrated, which has been developed recently by William Sellers & Co., Inc., Philadelphia, Pa. As usual in this type of lathe, the left-hand head is bolted to the bed in a fixed position, while the right-hand head is adjustable for putting in and taking out the mounted wheels. The adjustment of the sliding head is accomplished by a motor, driving through a slip clutch to insure the proper pressure being put upon the lathe centers. This also provides a safeguard against overstrain or breakage, during adjustment. The heads are massive and each one carries a rotating spindle with an internal geared face plate. A sliding spindle supports the conical centers which are adjustable longitudinally to suit the different relations of the tire to the ends of the axle. Hand-wheels are provided at the ends of the heads for adjusting the centers longitudinally and for locking them in position.

The bed is a heavy iron casting of box construction with the center line of the spindle carried vertically over the back shear, insuring that the resultant pressures due to the cuts will fall within the limits of the base, even for the largest diameter wheels. This feature is important in eliminating deflection and chatter.

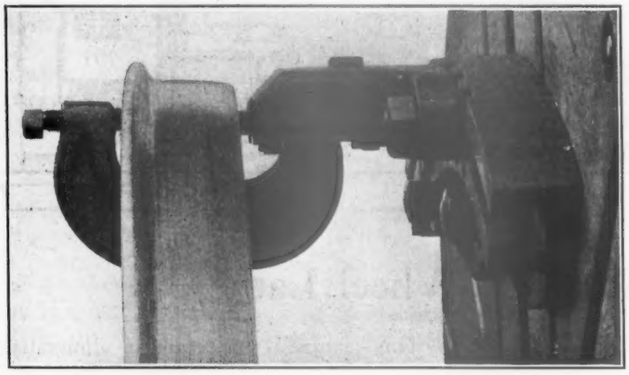
All of the tools necessary to complete the turning, from roughing to form finishing, are assembled and carried in turrets mounted on top of each tool slide as illustrated. In order to release the clamp and lock for the turret, preparatory to bringing a set of tools into operation, it is only necessary to make a slight turn of the clamp pin in the center and raise the locking cams *A* as illustrated. After swinging the turret 90 deg. the locking cams are dropped into place and the clamp pin given a portion of a turn, fixing the tools in position for the desired cut.



Sellers 90-in. Driving Wheel Lathe Equipped with Direct Current Motor Device

Another important feature is in the method of driving the wheels under the cut. On each of the face-plates are mounted two patented C-clamp drivers, illustrated. These drivers consist of sub-bases quickly and easily adjustable in the T-slots of the face-plate for the varying diameters of the wheels. The driver bases have a circumferential adjustment on the sub-bases to compensate for the layout of spokes and counterweights for different types of wheels and each driver base carries a sliding driver bit of hardened steel, with serrated teeth, the edges of which are pulled against the outer

side of the tire by a C-clamp. Owing to the freedom of the bit and C-clamp to move or float endwise with relation to the driving base and face-plate, this type of driver accommodates itself to the rim of the wheel and does not have any tendency to distort the rim, while holding and driving it firmly into the cut. As there are only two drivers required



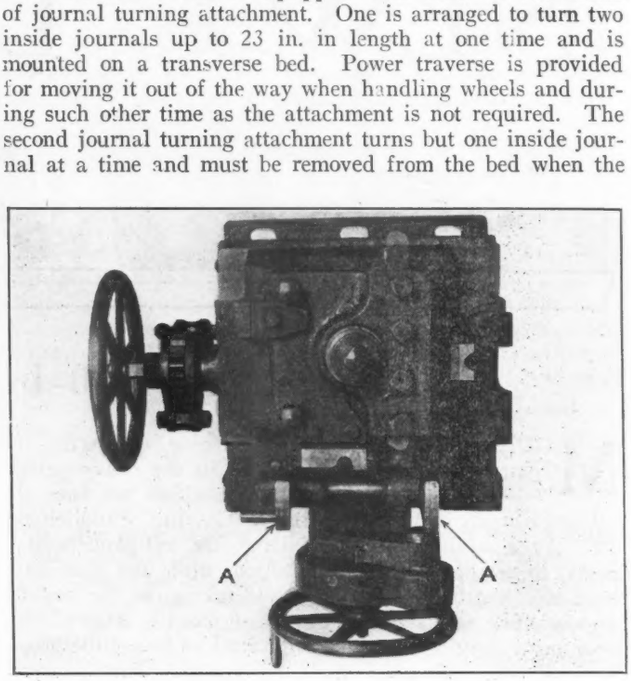
Non-Distorting Arrangement for Bolting Tire to Face Plate

on each face-plate, the amount of time and effort consumed in clamping is reduced to a minimum.

Difficulty from grit on the slides has been overcome by making the wearing surfaces of hardened steel. These surfaces are carefully ground and fitted and oil pockets filled with woolen waste are used as reservoirs for supplying lubrication.

The drive for this machine is simple, no change gears being used in the direct current drive, except for changing the range from the wheel turning to journal turning speeds. A 50-hp. motor with a three to one speed variation produces a range sufficient to cover all requirements. The speeds are from ½ to 1½ r.p.m. for wheel turning and from 3½ to 10¾ r.p.m. for journal turning. When alternating current drive is furnished, a geared speed change device is substituted for the variable speed motor and this in turn is driven by the alternating current motor coupled directly to it.

This machine can be equipped with either of two forms of journal turning attachment. One is arranged to turn two inside journals up to 23 in. in length at one time and is mounted on a transverse bed. Power traverse is provided for moving it out of the way when handling wheels and during such other time as the attachment is not required. The second journal turning attachment turns but one inside journal at a time and must be removed from the bed when the



Tool Slide and Turret Equipped with Roughing Tool, Flange Roughing Tool, Flange and Tread Finishing Tool and Chamfering Tool

wheels are being turned. Both of these attachments have a power cross feed for facing hub liners, etc. The quartering attachment consists of a separate boring head driven by an independent motor and mounted upon one or both heads of the machine.

Buckeye Six-Wheel Freight Car Truck

IN THE description of the Virginian 120-ton coal car, published in the March issue, brief reference was made to the six-wheel truck manufactured by the Buckeye Steel Castings Company, Columbus, Ohio. The new design which was used on 500 of these cars differs in several respects from the earlier form of this truck.

These trucks are of much interest, not only as a new development in high capacity freight truck design, but especially because they are designed to retain practically all of the fundamental advantages which have contributed to the recognized success of the present type of A. R. A. four-wheel cast steel truck.

Generally speaking, this latter type of truck owes its popularity principally to the following: (1) Perfect equalization of load regardless of condition of springs or tracks. (2) Accessibility of parts for maintenance and inspection. (3) Flexibility and short wheel base, facilitating operation over uneven tracks, inclines and sharp curves. (4) Brake sus-

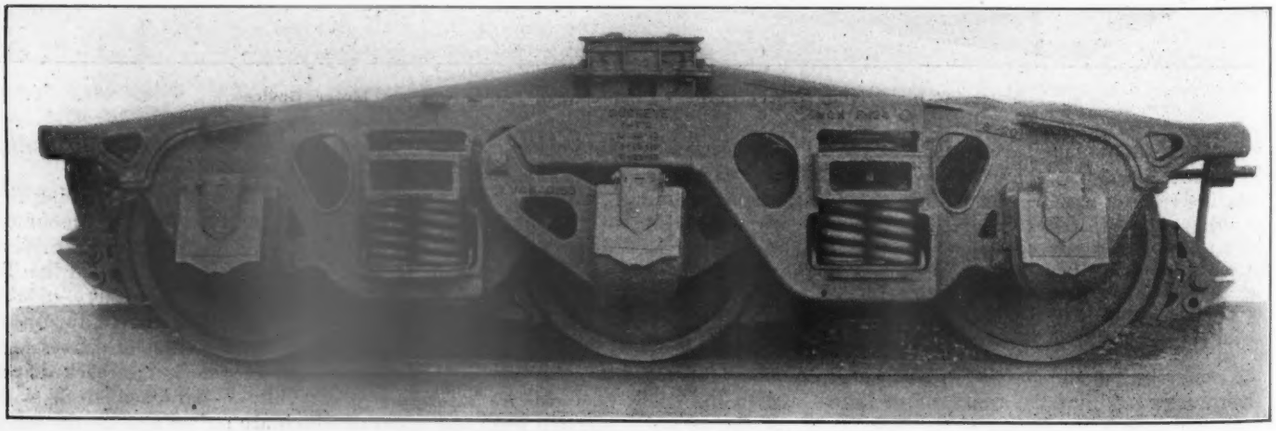


Fig. 1—A Side View of the Buckeye Six-Wheel Truck

pension arranged from parts independent of spring travel. (5) Safety of the detail structures by avoiding having any part carrying load subjected to direct tension.

Method of Equalization

The equalization of the load in the Buckeye six-wheel truck is accomplished by the use of the equalizer casting which engages the center journal as shown in Fig. 1. The side frame castings are so designed that two-thirds of each spring load is supported by the adjacent outside axle and one-third by one arm of the equalizer. Each journal of a given side of a truck, therefore, receives one-third of the total spring load on that side and furthermore the equalizer pre-

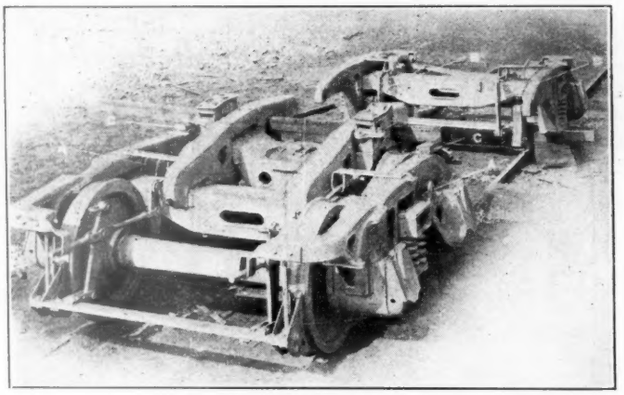


Fig. 2—Longitudinal Bolsters Raised and Four-Wheel Section of Truck Rolled Out

cludes the possibility of the springs receiving unequal loads on the same side of the truck. This feature affords extreme flexibility in the side members.

Maintenance and Inspection

In former designs of six-wheel trucks replacement of axles, particularly the middle axles, has been accomplished only by the use of special facilities such as drop pits, or overhead cranes. Replacement of bolsters required cutting away rivets and complete dismantling of the truck.

Where large numbers of cars with six-wheel trucks must be maintained in constant service, facilitating the routine work of upkeep is of great importance. The Buckeye truck in its present form is a remarkable advance in this respect. All the parts are of such size and are so disposed with relation to each other that light repairs such as changing bolsters, axles and springs are readily accomplished even in places where no special facilities are at hand other than those used in connection with four-wheel truck repairs.

The simple method employed in the removal of the middle pair of wheels is deserving of special mention. The two consecutive steps are shown in Figs. 2 and 3. After removing the bolts, *A*, Fig. 2, from the ends of the equalizer arm and the brake pin, *B*, the two longitudinal bolsters are disengaged from one transverse bolster by tilting them upward so that the truck may be separated as in Fig. 2. Then by placing jacks under the spring seats at *D*, Fig. 3, and removing the equalizer bolts at *F*, the center axle is relieved entirely of its load and can be rolled clear as shown in the illustration.

To facilitate replacement of the transverse bolster, the bolster opening in the frame in designed similar to that of a four-wheel truck frame. The spring seat casting, which carries the brake brackets for the inside brake beams, is separate from the frame. Hence, by jacking up the longitudinal bolsters and removing springs and spring seat castings, the transverse bolster may be replaced in a manner similar to that used with four-wheel trucks.

As will be noted from Fig. 4, the use of a separately constructed spring seat and brake hanger casting introduces another advantage, namely, that it permits of making all side frame castings identically alike. This is a distinct advantage, both in the manufacture of the trucks and in the upkeep of repair part stocks. As an aid to inspection, it is to be observed that all springs in the Buckeye truck are visible and arranged in groups of four in the bolster opening of the side frames as in four-wheel trucks.

Comparing the truck construction shown in the drawing with that shown in the photographs, it will be noted that the former illustrates the use of A. R. A. type journal boxes, also a different construction of end brake hanger. Trucks with these modifications are used only experimentally, the Virginian standard design in all other respects being as shown in the photographs.

Flexibility and Short Wheel Base

By reason of the side frame and bolster construction, the Buckeye truck retains all of the flexibility of the four-wheel truck. Besides providing vertical flexibility, the Buckeye type of equalizer makes possible the extremely short wheel base of 8 ft. 2 in. Due to the necessity of making the brake parts interchangeable with those of another type of truck of a longer wheel base, the wheel base on the Buckeye trucks on the Virginian cars was increased four inches and is therefore 8 ft. 6 in. as shown in the drawing. The clasp brake rigging used in the Buckeye trucks is suspended entirely from parts independent of the spring travel.

Safety of Detail Structures

A notable accomplishment in the Buckeye truck design is the avoidance of load carrying members subjected solely to tension. In the Buckeye trucks, the parts that carry the loads are so designed and assembled with relation to each other that they are not subjected to direct tension stresses: i. e., the parts perform the function of beams rather than that of hangers. From the foregoing it will be noted that prac-

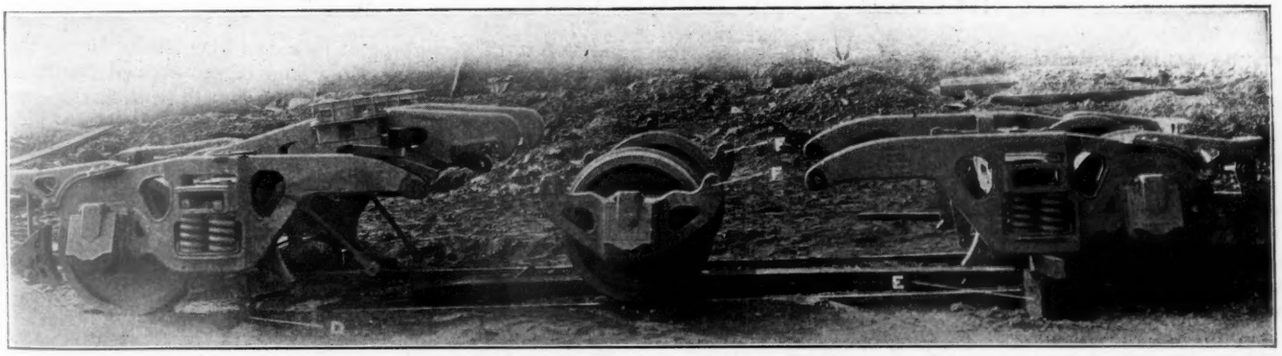


Fig. 3—Center Wheels Ready for Removal

tically all of the important fundamentals of the four-wheel truck have been observed in this six-wheel truck design.

Specification and Weights

The Buckeye trucks as used on the Virginian were designed for use with car bodies having either 12⅞ in. or 18½ in. center sill spacing and with truck centers of 36 ft. 1¾ in. The design conditions specified that the cars should operate successfully over tracks having a horizontal curvature of 20 deg. and a vertical curvature of 350 ft. radius. These conditions have been met with a safe margin as evidenced by experimental tests where cars negotiated curves of more than 30 deg. curvature.

The general specifications of the trucks are as follows:

Wheel base	8 ft. 6 in.
Center plate height (light car body)	27⅛ in.
Side bearing height (light car body)	42 11/16 in.
Center to center of side bearings	48 in.
Axles—A. R. A.	6 in. by 11 in.
Wheels	Rolled steel
Brake equipment	Clasp brake with vertical levers
Springs	Virginian No. 28 (Same as A. R. A. Class D, except 1 5/16 and 11/16 in. bars)
Free height of springs including caps	8½ in.
Solid height of springs	7 in.
Side bearings	Stucki
Brasses and wedges	A. R. A. standard

The total weight of the trucks per car is 37,000 lb., distributed as follows: cast steel parts, 14,500 lb.; brake material, 3,800 lb.; springs, 1,100 lb.; wheels and axles, 15,200 lb., and other material, 2,400 lb.

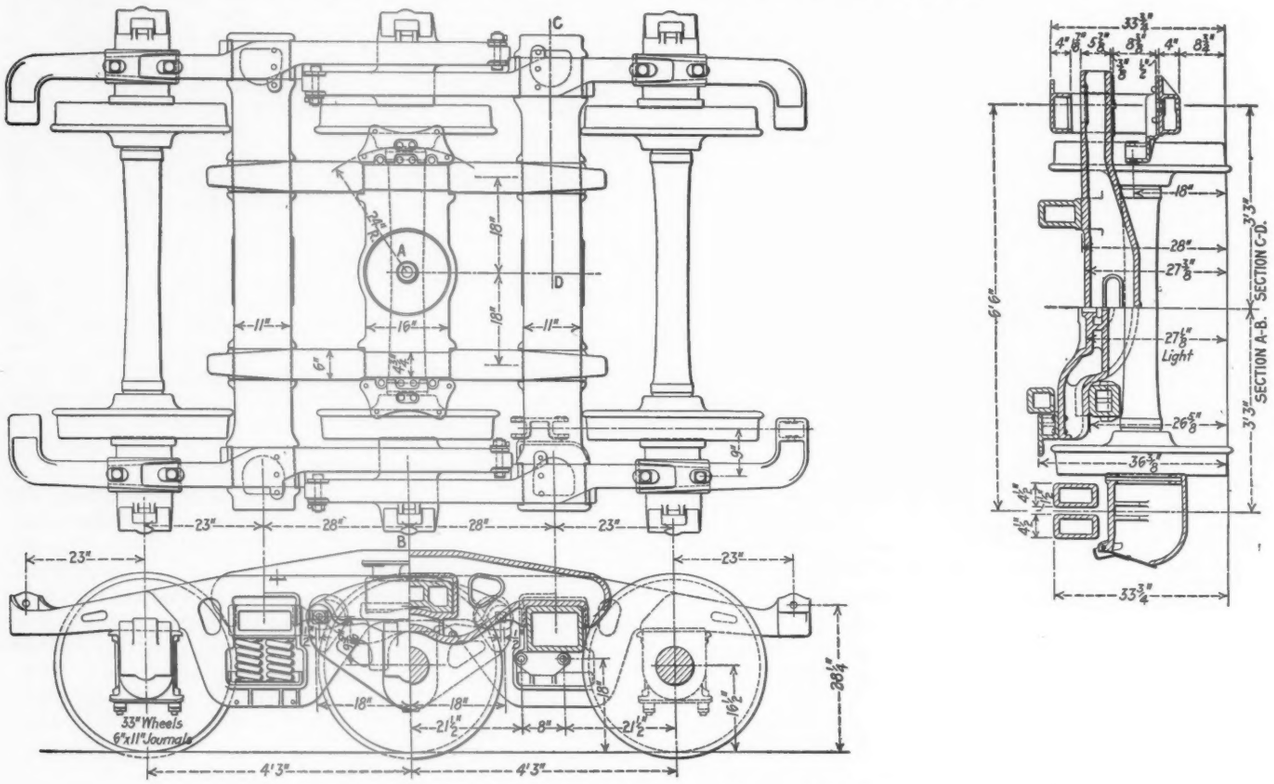


Fig. 4—Assembly of the Buckeye Six-Wheel Truck

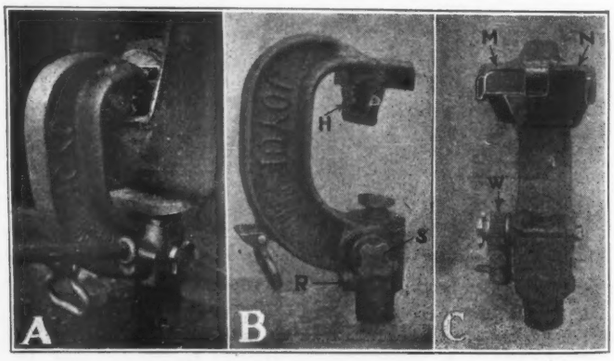
Universal Type Suspension Journal Jack

TO facilitate the changing of car journal brasses the Joyce-Gridland Company, Dayton, Ohio, has added to its line of lifting jacks a new universal suspension journal jack, illustrated. This jack is called universal because only one size is required for use on any standard M.C.B. journal box. Simplicity and a minimum number of parts are features of the jack, which is provided with ball bearings throughout.

The principal advantage of the new jack and its method of use is shown at *A* in the illustration. It will be noted that the jack is applied over the journal and under the box and operation of the ratchet relieves the weight from the brass, allowing it to be taken out over the jack. This operation is quickly performed since there is no lost motion, and it is not necessary to spot a car in such a manner that the journal box will be over a tie. All blocking and jacking under the journal box is eliminated; also any arrangement to hold the wheel on the rail as the box is lifted.

Another important advantage results from the fact that it is impossible to run the new jack out under a load, since the open portion of the box will go up against the top of the jack and stop it. The old type of jack could be driven out beyond the safety limits of the screw and often dropped the load.

Referring to sections *B* and *C* of the illustration the construction and operation of the jack will be evident. Two intermeshing tooth-type jaws *M* and *N* are adjustable to-



Improved Type of Car Journal Jack

gether or apart by means of hand-wheel *H* to fit any size journal desired. These jaws fit on over the collar of the journal at such a point as not to interfere with the removal of brass or wedge. Ratchet *R*, in conjunction with the fine tooth ratchet wheel *W* operates the lifting screw and the leverage is such as to give ample power. A speeding button *S* hurries the action of the jack to the point of lift. It is stated that only a short lever is required to lift the heaviest loads and that the principal merit of the device is in the elimination of lost motion, a rise of from ½ in. to ¾ in. enabling the wedge and brass to be removed. The jack is light, weighing only 60 lb. and can be readily carried over a man's shoulder, as the frame is broad and flat.

It is stated that thorough tests in actual service were followed by several minor changes and improvements and that the jack is now ready for the market. In places where the average work of a brassing crew was 22 boxes a day, one man was able to brass 39 boxes the first day and 44 the second day. This work was all done by one man where two had previously been employed.

Pneumatic Crude Oil Flange Lubricator

THE question of flange lubrication to eliminate undue wear of flanges and rails is a serious one and a device designed to eliminate difficulty from this cause has been developed by the Hoofer Manufacturing Company, Chicago. In construction the device consists of a pneumatically operated crude oil lubricator (Fig. 1) of either

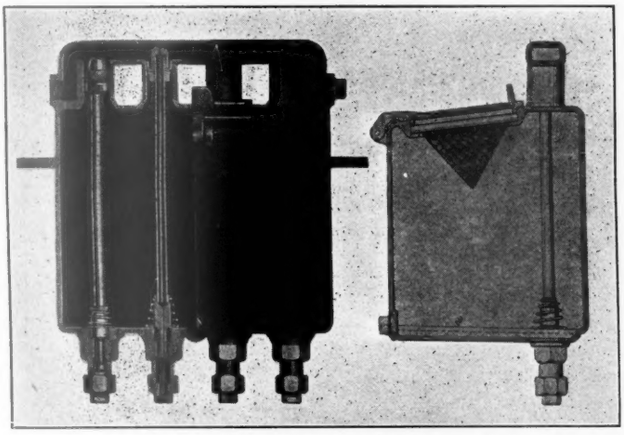


Fig. 1—Hoofer Four-Feed Automatic Flange Lubricator

four or six feed type which is installed above or below the running-board or secured to the locomotive frame at any convenient position for filling with oil. Air pressure for operating the discharge pistons is supplied from the brake system and a lever or gear controlled air valve (Fig. 2) is installed in the pipe at any convenient place. This valve

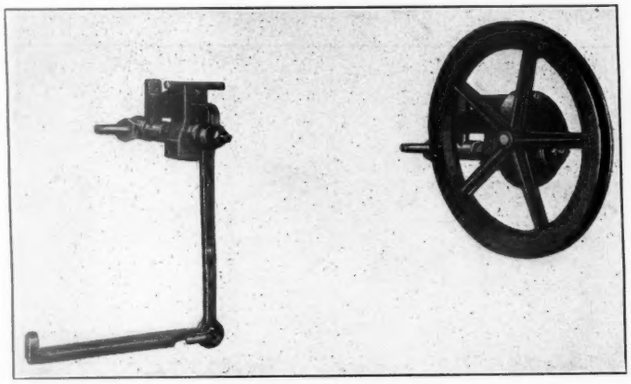


Fig. 2—Lever and Gear Operated Control Valves

is provided to control the supply of air pressure to the top sides of the oil discharge pistons. The air thus supplied acts to force the pistons downward into their respective oil cylinders in the bottom of the lubricator, thus discharging oil into oil pipes which lead to the wheels. There are small vents or passages through the caps on the tops of the oil discharge pistons, so that a small amount of air is free to pass through which acts as a means of conveying each charge of oil to the wheel flanges. In this manner measured quantities of oil are delivered at regular distances to an oil distributor (Fig. 3) at each wheel. The amount of oil discharged may be regulated by interchangeable nipples in the bottom of the lubricator, as these nipples are constructed with cylinders of various depths whereby any size may be replaced by another of the desired capacity.

The construction of the lubricator is simple, with few parts to get out of order. While the four-feed type is illustrated, the six-feed type is recommended for Atlantic or Pacific locomotives, for oiling the truck wheels also.

Two forms of air valve are illustrated in Fig. 2. The lever controlled air valve shown at the left is adapted for switch engines. It may be installed in the air supply pipes in any convenient place near the back of the engine where a connecting rod may be extended from its lever to the frame of the locomotive tender. By this means it is actuated by the relative swing between the engine and the tender

Fig. 3—Device for Distributing Oil to the Flange

when the locomotive is entering a curve, and oil is supplied to the flanges on curves only. The valve control mechanism is so constructed that when the lever is moved either way the valve opens for an instant and automatically closes when a pressure of 50 lb. is attained in the air cylinders of the lubricator.

The gear controlled air valve, shown at the right in Fig. 2, is generally adopted for locomotives in road service. It may be installed in the air supply pipes in any convenient place where a coil spring belt may be operated over the sheave of the valve and the axle of the locomotive. By this means it is actuated at regular distances traveled, and oil is supplied to the flanges at regular intervals. The valve is opened by the gear, but automatically closes when a pressure of 50 lb. has been obtained in the air cylinders.

Proper oil distribution is most essential to successful flange lubrication and the distributor shoe, shown in Fig. 3, has been designed especially for this purpose. The outlet passage for the oil is constantly maintained in contact with that side of the flange which wears against the rail, and the wearing action of the wheel flange against this outlet passage causes it to fit the flange closely. The oil is thus applied in a thin film upon the particular portion of flange where it is most needed. Owing to centrifugal force a revolving wheel tends to throw off the oil. This difficulty is completely overcome by the pneumatic feature of delivering the oil through the oil passages and forcing it into the

crevice of the wheel flange by a current of air under pressure. The oil distributor consists of a cast iron hollow shoe through which an oil passage extends parallel with and partially within the wall of the shoe, nearest the tread side. These shoes are secured to hangers by tapered keys which may be removed with a hammer when necessary to renew the shoes. The hanger spring holds the oil distributor in a well-balanced position over the flange at all times.

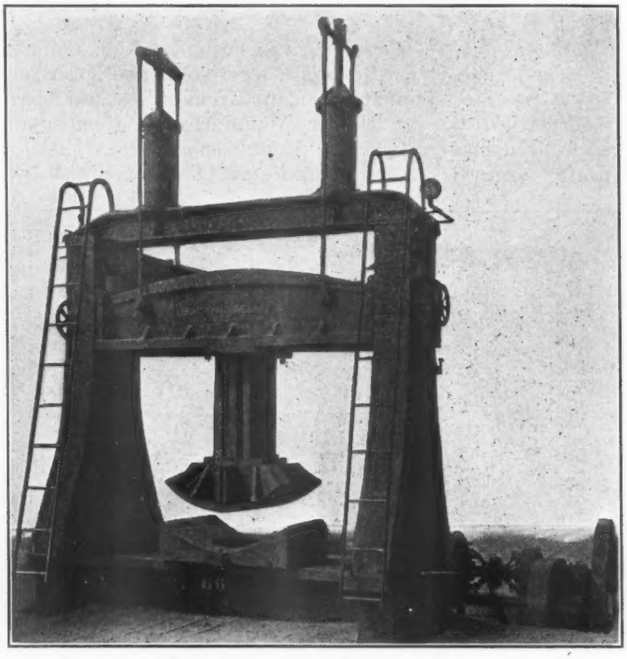
Vertical Bulldozer for Steel Car Work

THE principal features of a new vertical bulldozer, made by the Beatty Machine & Mfg. Co., Hammond, Ind., are its simplicity of construction and the location of driving parts. The main shaft is mounted through the lower bed instead of overhead, and the main side gears are enclosed in a box type housing, with all intermediate gears fully enclosed. Clutches and high-speed bearings are easily accessible.

The general construction includes a heavy bed or table casting with main shaft, side gears and connecting rod to the crosshead. A 4 in. vertical adjustment connection at each end of the crosshead eliminates loss of time in changing dies. The crosshead is fitted at both ends with bronze tapered gibs for adjustment in case of wear to the slides. Air cylinders are used for counter-balancing the weight of the ram. All gearing is of cast steel with cut teeth. The machine is also fitted with forward and reverse clutches which permit reversal at any point of the stroke. Arrangements for either belt or direct connected motor drive can be made.

The vertical bulldozer is especially adapted to steel car and car repair work for the pressing and forming of such parts as diaphragms, stakes, roof carlines, end sills and a general line of sheet metal plate and bar parts. The dies which are attached to the machine illustrated are used for forming plates in tank car tanks, giving the plate full radius, overcoming the difficulty experienced in rolling these plates and eliminating the straight edge at each side.

The machine is built in sizes up to and including 500 tons ram pressure. The distance between housings ranges from 8 to 12 ft.; vertical die space with stroke down and adjustment center, 24 to 72 in.; stroke, 18 to 24 in.; stroke per minute (small size, 16), large size, 8 to 10. The smallest size weighs approximately 24,000 and the largest 120,000 lb.



Beatty Vertical Bulldozer

Clutch Tap and Die Holder of Simple Design

SIMPLICITY and relatively few parts are features of a new clutch tap and die holder developed by the Warner & Swasey Company, Cleveland, Ohio, and illustrated in Fig. 1. This clutch has been patented and because of its general adaptability should prove extremely useful in railroad machine shops. Only eight parts are used in the construction of this tool, as shown in Fig. 2, and all the principles of an older model embodying 23 parts are incorporated. Either right or left-hand dies or taps can be held in the new holder which thus becomes two tools in one. To change from right to left, a screw-driver is the only tool required. After releasing the small tightening screw, the rest can easily be done with the hands. The only difference in the tool when used for right or left-hand work is in the position of the pawl. To change from one to the other, the pawl it turned half way around in its hole, a small pin holding the pawl in whichever position it is placed.

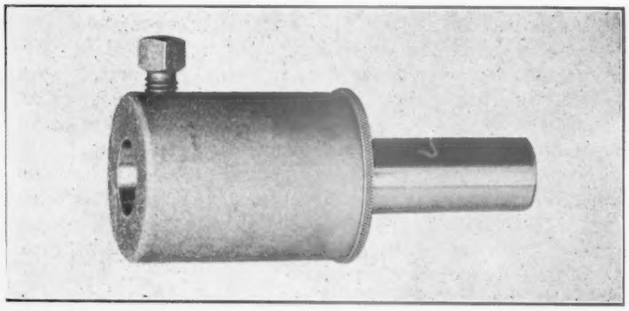


Fig. 1—Simplified Warner & Swasey Clutch Tap and Die Holder

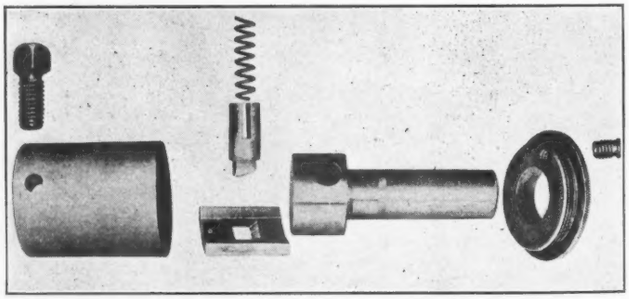


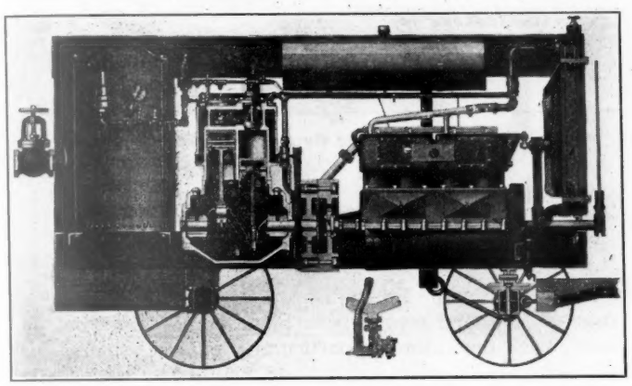
Fig. 2—View Showing Parts of Clutch Tap and Die Holder

When threading on a turret lathe, the pawl holds the tool rigid by a metal to metal contact, until the turret stop is reached. Then the head moves forward on the work, pulls the cam over the pawl and releases the head, thus allowing

it to revolve freely. The spring cushions the pawl so that the release is without jar and practically noiseless. The material in each part has been carefully selected and designed to stand the work required of it. Arrangements have been made for the easy cleaning and oiling of the tool which insures reliability of operation and long life. This clutch tap and die holder is valuable for use in machine shops, particularly on brass work.

Gasoline-Driven Portable Air Compressor

SUPPLEMENTING its line of portable air compressors, the Chicago Pneumatic Tool Company, New York, announces a new gasoline-driven, portable air compressor which is said to combine large capacity with light weight.



Portable Air Compressor with Capacity of 128 Cu. Ft. of Free Air per Minute

The compressor is of the two-cylinder, single-acting, vertical type with the cylinders cast en bloc and entirely water-jacketed. The gasoline engine is of the tractor-marine, four-stroke cycle, four-cylinder type, the compressor and engine-shaft being connected by a flexible coupling which serves also as a flywheel.

The crank case is completely enclosed and is provided with large openings for inspection, cleaning or adjustment. The bearings, which are cast integral with the crank case, are accessible and can be easily adjusted by means of liners. Baffles are provided to prevent an excess of oil from working above the pistons into the cylinders.

A pneumatic throttle working automatically in conjunction with the engine governor and the differential unloader of the compressor, throttles down the speed of the engine when the compressor is running unloaded. By this means, it is said that a marked saving of both fuel and lubricant is effected. The compressor illustrated has a capacity of 128 cu. ft. of free air per min. and delivers this air at a pressure of 100 lb. per sq. in.

Both compressor and engine are cooled by a system designed to be positive and reliable. Two centrifugal circulating water pumps, one driven from the magneto shaft and the other belted to the compressor crank-shaft, force water through jackets of liberal size and through a large radiator, which is cooled by a powerful fan belted directly to the engine shaft. Oil from the crank case of the compressor is picked up by an oil thrower attached to the connecting rod and is thrown into channels which lead to all the bearings. Some of this oil is carried by the pistons into the cylinders, which are thus thoroughly lubricated.

A receiver of large capacity is mounted directly on the truck and is equipped with safety valve, drain valve, discharge valve and pressure gage. The entire equipment is firmly mounted upon an all-steel truck, having a steel plate canopy top and sheet steel sides which completely enclose the outfit. The sides can be locked in place.

Air-Operated Hoist of Novel Design

AN air-operated hoist embodying several novel features in design has been developed recently by the Sullivan Machinery Company, Chicago. This hoist was designed to meet the demand for a small, compact and powerful portable engine, for general hoisting work within its range. It may be mounted on a cross-bar or column, bolted to a timber, or fastened to the wall or floor for miscellaneous hoisting or hauling jobs. Fig. 1 shows the device hauling a box car to the shipping door. The capacity of the hoist is 1,500 lb. dead load, lifted vertically at 100 ft. per min., using an air pressure of 80 lb. per sq. in. The device is known as the Turbinair, weighs 285 lb. and the drum will accommodate a maximum of 500 ft. of 5/ 16 in. wire rope cable.

Simplicity is an important feature of the device which consists of a cylindrical drum, mounted on a steel frame and completely enclosing the operating mechanism. Two cylindrical rotors, one of which is shown in Fig. 2, are provided with right and left-hand helical flutes or vanes converging to a spur tooth in the center. The two rotors mesh together as they revolve under the influence of the incoming air. Reduction gearing is arranged to drive the drum shell.

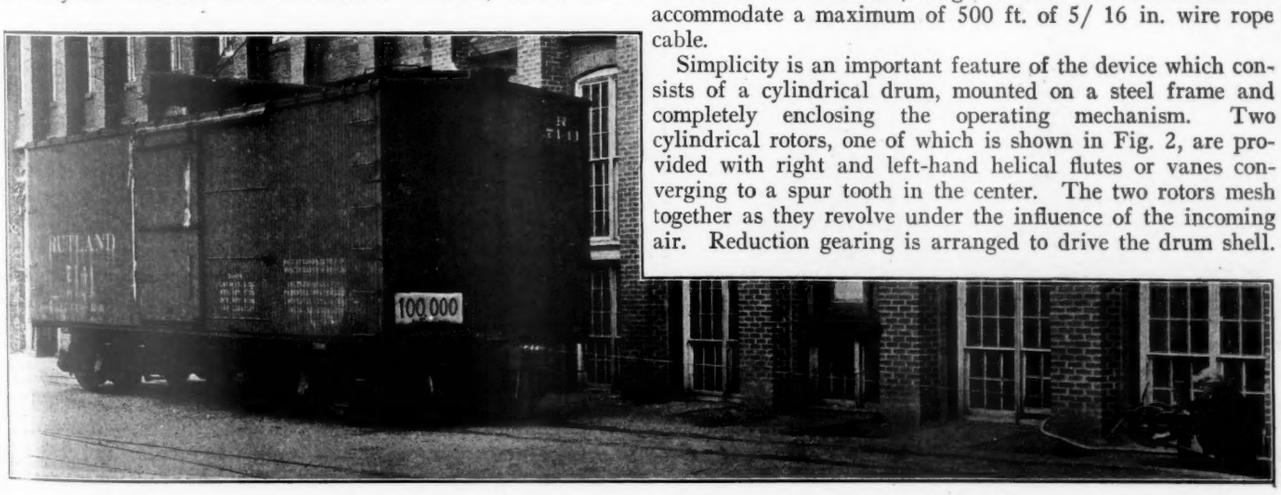


Fig. 1—Turbinair Hoist Arranged for Shifting Freight Cars

This motor is said to develop a high starting torque, to be economical in the development of power, as it uses the air expansively and to have shown long life and sustained efficiency in service.

The hoist is provided with a friction clutch and brake and when both handles are released the rope may be pulled freely from the drum. The friction clutch may be locked in position and the load raised or lowered, being controlled entirely by the throttle valve. The brake is of the band type and is of sufficient strength to hold any load within the capacity of the hoist. It works smoothly, thus putting no unnecessary stress on either the mechanism or the rope.

Air is admitted at the axis of the drum through a hollow shaft, and the motor revolves with the drum. Ball bearings are employed and all mechanism is totally enclosed, being well lubricated. The rotors are lubricated by an automatic oiler. The hoist is quiet in operation, therefore, and does not interfere with signals and instructions being transmitted. The machine is recommended for any duty for which portable column air hoists are generally used. The power developed is 4½ h. p.

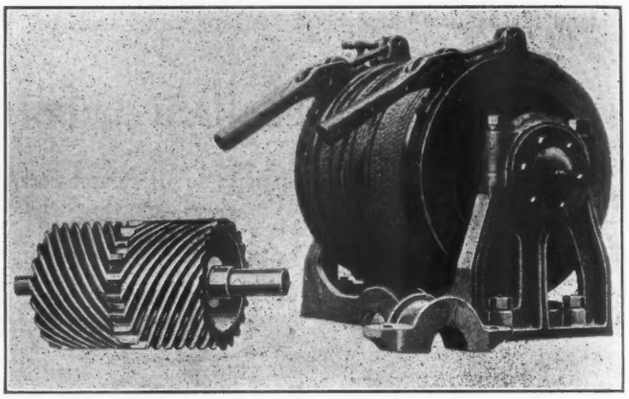
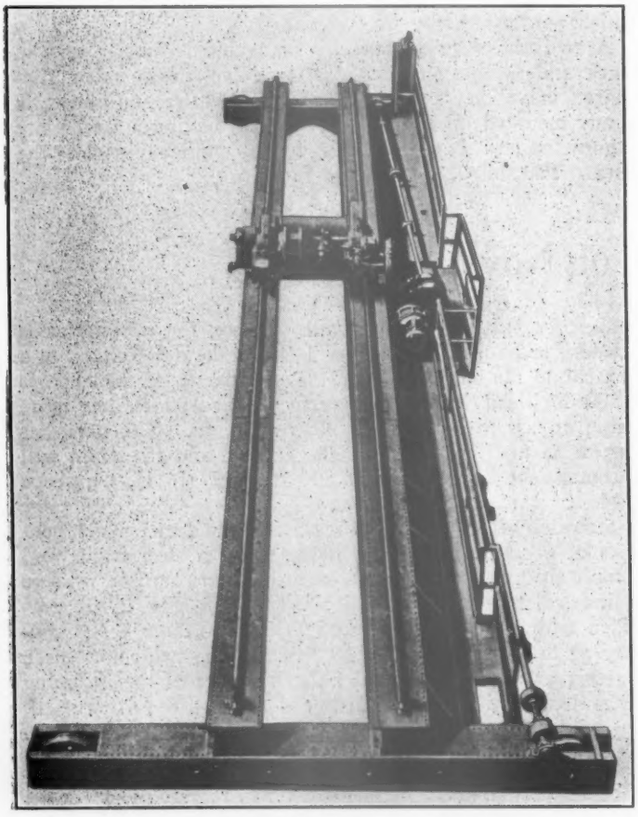


Fig. 2—View of One of the Rotors and Assembled Hoist

Driving Mechanism for Roundhouse Crane

A NEW ten-ton overhead roundhouse crane, involving two features of particular interest, has been installed recently by the Champion Engineering Company, Kenton, Ohio. The first of these features is the construction of the driving mechanism in such a way as to enable the truck supporting wheels to be of the same diameter, the parts of the driving mechanism being interchangeable and designed to provide positive, reliable operation. The second unusual feature is an arrangement for correcting the tendency of a crane to get out of square. This is applicable not only to the roundhouse crane illustrated but to all electric traveling cranes of the overhead type. Such cranes get "out of square" with the runways, particularly on long spans, due to various causes; one of the driving wheels may wear faster or have less traction than the mating one at the opposite end of the truck; the truck may not have been placed squarely on the girders in the first place; a sudden stop after traveling at high speed with the crane fully loaded at one end also tends to get the crane out of square. In the crane, illustrated herewith, provision has been made for the rectification of this condition.



Champion 10-Ton Roundhouse Crane

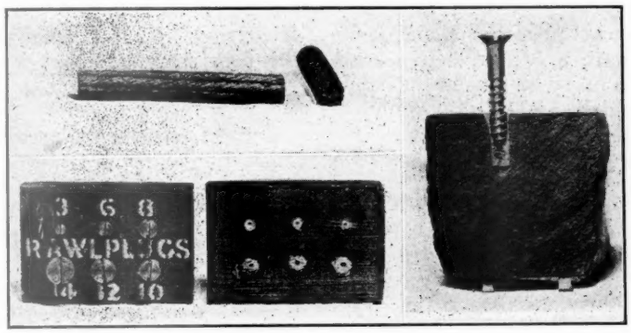
In order to drive the crane properly around a curved structure, all supporting wheels being of the same diameter, the mechanism shown in the illustration has been installed. It will be noticed that the electric motor is mounted in the middle of the span and is provided with a shaft on which are keyed two pinions of different diameters. These pinions mesh with two gears keyed to sections of the drive shaft, one section extending to the inner radius and the other to the outer radius. The diameters of the two driving pinions and gears are such as to revolve the supporting truck wheels at the proper porportional speeds and maintain the crane in the correct radial position.

In order to reline the crane, should it become out of square, a clutch has been placed between the two driving pinions so that either pinion may be operated independently of the other. When the crane becomes out of square, therefore, this clutch is used to turn one pinion slightly while the other is still and place the crane back in a radial position. When the crane is properly alined the clutch is reengaged, both pinions being operated at the same speed by the motor shaft. This method of drive can be applied to cranes operating on straight tracks if the gears are properly proportioned and the clutch normally engaged.

Should a crane equipped with this form of drive become out of square to such an extent that the truck wheel flanges are binding on the track, causing the usual difficulties and troubles, the truck can be readily made square by means of the clutch between the two driving pinions. The entire design of the crane and driving mechanism has been made with a view to providing positive and reliable operation. In this way many locomotive delays are prevented and the work of maintaining running repairs is greatly facilitated because of the ease in moving heavy parts from one track or department to another.

Making Screws Hold in Any Material

THERE has recently been placed on the market a device known as the Rawlplug, which permits fixing an ordinary screw into any kind of material so that it will hold permanently. By its use screws may be made to hold in metal, plaster, brick, concrete, slate, glass, or, in fact, any substance. The Rawlplug is especially advantageous in railroad work in connection with maintenance, signal and interlocking systems and for the original installation of interior trimming and fixtures for both steel and wooden coaches. Its use solves the problem of replacing screws in repair work



A Rawlplug; Several Sizes in Place, with and without Screws; Cross-section Showing Plug Expanded and Threads Cut by Screw.

on the interior of cars, as an old screw can be removed and again put in place permanently in the same hole by simply inserting a Rawlplug before placing the screw. The use of Rawlplugs in metal eliminates the need for tapping and does away with tapping costs.

Rawlplugs are hollow tubes of stiffened, longitudinal strands of jute fibre, so cemented that once in place they do not crumble or pulp and are unaffected by moisture or temperature changes. They are installed by first making a hole with any common drilling tool or with the Rawlplug tool in the material into which the screw is to be fixed, this hole being the proper size to receive the Rawlplug with a sliding fit. The plug is inserted into the hole and as the screw is turned home in the plug, the fibre strands expand and enter every minute pore of the material, practically becoming an integral part of it. The screw forms a thread in the fibre plug. The threads hold securely, but permit withdrawing and reinserting the screw in the usual manner whenever desired.

Tests conducted under actual working conditions showed that Rawlplugs withstood a direct pull, expressed in pounds, varying from 150 in plaster up to 600 in iron, or 1,250 in common brick for a number 14, 2 in. screw. These results were obtained by a direct pull and the plugs withstood a correspondingly greater stress in every case for an indirect pull.

Rawlplugs offer an economical method of fixing screws permanently. It is stated that their low cost will save about one-half the initial expense and, because they require small holes, will save about five-sixths the time necessary to drill and fix in place. They give a neat finished appearance as the head of the screw entirely covers the hole. Other advantages of this device include the ability to absorb and resist vibration and the fact that the plugs do not fracture material when expanded. They can be successfully used in conjunction with ordinary wire nails.

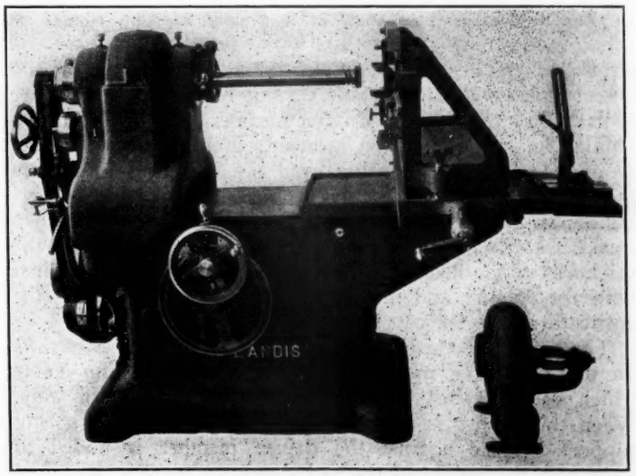
Rawlplugs are made in sizes to receive all screws from a number 1 to a number 32 and are furnished in ½ in., ⅝ in., ¾ in., 1 in., 1½ in. and 2 in. lengths. For convenience, tools for forming holes for Rawlplugs are made in sizes to correspond with plug and screw sizes. For example, a number 8 tool makes a hole of the proper size to receive a number 8 plug and a number 8 screw. Any type of drill may be used, however, for making the holes.

Rawlplugs are packed in boxes of 100 plugs of any one or assorted sizes. There are also various complete kits which include plugs, screws and tools. This product is manufactured by the Rawlplug Company, New York, which is represented in the railroad field by the Universal Packing & Service Company, Chicago.

Internal Grinder for Irregular Parts

AN internal grinding machine has been developed recently by the Landis Tool Company, Waynesboro, Pa., for regrinding automobile cylinders, but it is also adapted to the internal grinding of miscellaneous irregular machine parts in railroad and other shops. The center of rotation of the grinding wheel spindle is 10 in. above the top of the work carriage so that large castings may be easily handled with no extra or special fixtures. The spindle regularly furnished will grind 15 in. deep and eccentric adjustment of the spindle, ranging from 1/16 in. to 1 1/16 in., permits grinding holes as large as 5⅝ in. in diameter with standard 3½-in. grinding wheels. Two spindle driving pulleys are furnished to give the correct peripheral speed of approximately 6,500 ft. per min. with 3½ in. and 4½ in. diameter grinding wheels. Extra wheel spindles and sleeves for grinding 20 in. and 22 in. deep, or for diameters larger than 6 in., can be furnished if desired.

The work carrying fixture is an open angle plate design with two adjustable work clamping bars. The work to be ground is securely clamped to the bars by two heavy machine clamps of ample capacity. A distinctive feature of this fixture is the arrangement for quickly and accurately alining the work in vertical position to the center of spindle rotation. A centering bar fits neatly into two slots milled in the frame of the work carrying fixture and carries two adjustable bear-



Landis Internal Grinding Machine

ing brackets. Before clamping the work onto the machine, these centering brackets are inserted into the hole to be ground to ascertain the exact size. They are set to this dimension and the work is then lifted to the machine and fitted over the brackets of the alining bar, where it is securely clamped to the work carrying fixture. After it is clamped in position, this alining bar is removed. If the work is not absolutely alined, minor adjustments can be made by a screw in front of the fixture which permits it to be raised or lowered as required.

The work carriage has a cross movement of 27½ in. and is mounted on a traveling carriage which operates on a flat and a dovetailed guide. Lubrication of these guides is assured by rollers running in pockets filled with oil. Traverse movement of the work carriage is automatic and reversing action is obtained by two self-locking adjustable dogs. These dogs are accurate in their functioning, which permits grinding close to shoulders. The speed of traverse is constant at 10 in. per min. and is independent of all other mechanisms. The maximum movement is 31½ in. The outside eccentric spindle which carries the wheel spindle eccentric sleeve runs in two wide-tapped bearings, and liners afford a correct running fit. The lower half of the bearing is cast as a part of the head, which makes it rigid and practically eliminates vibration at this point. The eccentric adjustment or cutting feed is obtained by the relative position of the two eccentric sleeves, one within the other. Feed is obtained by a sensitive mechanism mounted on the end of the outer sleeve. Provision is also made for the application of a crank for rapidly changing from one size hole to another.

The machine is arranged for either direct motor drive or for lineshaft drive through a small overhead countershaft. If motor drive is used, a 3-hp. motor operating at 1,150 r.p.m. furnishes ample power. If driving from a countershaft, a 3½-in. belt is used. The floor space occupied is 88 in. by 88 in. and the net weight of the machine is approximately 2,900 lb.

Floating Holder Corrects Spindle Misalinement

IN order to correct spindle misalinement in reaming, tapping, counterboring, and various other operations, the McCrosky Tool Corporation, Meadville, Pa., has recently developed the floating holder illustrated. Spindle misalinement may be either angular or parallel and this holder is designed to make corrections for both. The second important feature of this holder is its design to eliminate friction or strain preventing freedom of action of the cutting tool.

Referring to Fig. 1 which shows the holder disassembled, its construction and operation will be evident. It is composed of a driving member *A*, an intermediate floating member *B*, and a driven member *C*. The driving member is made in different styles and sizes to fit various spindles in which the holder may be used, three of these being shown

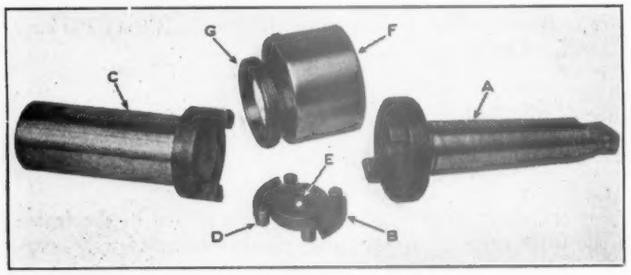


Fig. 1—Disassembled View of McCrosky Floating Holder

in Fig. 2. The driven member is also furnished in different styles and sizes to take various reamers, taps or other tools. Two lugs on the driving member interlock with two similar lugs on the driven member. Four hardened rollers *D* operate between these lugs and the intermediate floating member to remove all friction from the drive. In the center of the floating member is a hole containing a hardened steel ball *E*. This ball has a diameter greater than the thickness of the floating member and therefore bears against both the driving and driven members *A* and *C* taking the entire thrust of the cuts.

The housing *F*, which encloses the floating member, screws on to the driving member *A*. It has an adjusting collar which bears against *C* and regulates the amount of play. When this holder is used horizontally an adjustable spring support bearing against the driven member is added to counteract the weight of the tool shank.

It is evident from a consideration of the above that the rollers take the driving torque and in conjunction with the center ball permit movement in all directions practically without friction. This makes it possible for instance to ream a hole, true to size, straight and round, in spite of serious spindle misalinement. The holder is adaptable to

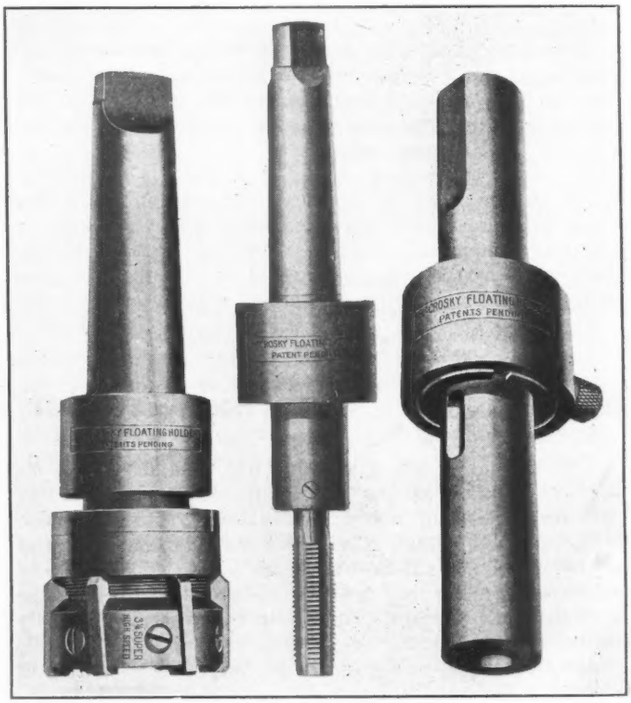


Fig. 2—Floating Holders for Reamers, Taps and Morse Taper Tools

use on drill presses, turret lathes, automatics, boring mills, engine lathes, and other similar machines.

THE POLISH RAILWAYS, which suffered heavily during the war, have been systematically improved since they were taken over by the Polish Government. The rolling stock is being gradually repaired and large additions have been made, due to the decision of the Inter-Allied Commission, which recognized Poland's right to the return of 481 locomotives that were taken by the Germans during their occupation. Of these 182 are already in service again.

Railway Mechanical Engineer

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WE GUARANTEE, that of this issue 8,850 copies were printed; that of these 8,850 copies 7,763 were mailed to regular paid subscribers; 7 were provided for counter and news company sales, 245 were mailed to advertisers; 32 were mailed to employees and correspondents and 803 were provided for new subscriptions, samples, copies lost in the mail and office use; that the total copies printed this year to date were 76,350, an average of 8,544 a week.

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The Union Pacific, on July 17, re-employed 1,500 men on its Mountain division who had been laid off with the slump in business.

The Chicago, Burlington & Quincy, on July 1, put on 1,500 workmen to repair grain and coal cars, according to E. P. Bracken, vice-president in charge of operation, to make ready for the expected heavy movement of these commodities.

About 2,000 shopmen of the Delaware & Hudson resumed work on July 5, after a general suspension of work lasting six weeks. Certain shops on the Baltimore & Ohio on the same day took back about 3,600 shopmen who had been furloughed for three weeks or more. It is said that at the Mount Clare shops of the Baltimore & Ohio, in Baltimore, the forces now aggregate about two-thirds the normal number.

An erroneous statement occurs in the sixth sentence of an article describing the Minich safety hand brake, published on page 1464 of the June *Railway Mechanical Engineer*. The sentence should read, "The usual brake chain is eliminated, being replaced by a connecting bar attached to the brake rod (or air brake lever on hopper cars)."

Locomotives

The National Railways of Mexico have ordered from the American Locomotive Company 20 Consolidation type locomotives, with a total weight in working order of 314,000 lb., and 7 Mikado type locomotives, with a total weight in working order of 440,000 lb.

Freight Cars

The Wabash has given an order to the Western Steel Car & Foundry Company for making repairs to 300 steel hopper cars of 40 tons' capacity.

The Western Pacific has ordered 25 30-yard extension side dump cars, of 50 tons' capacity, from the Clark Car Company, Pittsburgh, Pa.

The Illinois Central has contracted for the repair of 400 gondola cars with the Haskell & Barker Car Company.

Contracts for Car Repairs

The Illinois Central has awarded a contract to the General American Car Company, for rebuilding 600 all-steel gondola cars.

The Chicago & Illinois Midland has given a contract to the General American Car Company, for rebuilding 725 composite gondola cars.

The Missouri Pacific will have repairs made to 500 wooden box cars by the Sheffield Car Company.

Shop Construction

The Atchison, Topeka & Santa Fe is installing a new 120 ft. turntable at Winslow, Ariz., with company forces.

A New Technical Magazine

"Management Engineering" is the title of a new monthly publication issued by the Ronald Press, New York. Its contents are devoted to a discussion of the problems of management and production, the object as stated in the first issue being "to help executives better to discharge their duties in preparing, organizing and directing industry to secure maximum production." L. P. Alford is editor of "Management Engineering" and E. W. Tree, associate editor. Mr. Alford was formerly editor of the American Machinist and of Industrial Management. He is a vice-president of the American Society of Mechanical Engineers and chairman of the Management Division of that society.

Krupps' Output

Recent visitors in Germany report that Krupps is working to capacity in its locomotive and car shops. Their output at present is 20 locomotives per month, and the one thousandth freight car has recently been completed. This company is busy on locomotives for Russia and has a contract for tires for Russian locomotives. It is reported that the Prussian State Railways has a financial interest in the locomotive and car division of Krupps.

Roads Urged to Purchase Coal

Chairman Cuyler, of the Association of Railway Executives, has written to Chairman Clark, of the Interstate Commerce Commission, saying that his letter urging the railroads to purchase reserve supplies of coal as early as possible was read at a meeting of the member roads of the association in New York on July 1, and the chairman was instructed to transmit it to all roads with the request that they comply with the request of the commission in so far as it may be practicable. Mr. Cuyler said it was also ascertained that a very considerable number of roads had already made liberal purchases of coal.

Alcohol Locomotives in Brazil

In the vicinity of Pernambuco, Brazil, according to Consul C. R. Cameron, are some 80 sugar factories which operate approximately 800 miles of railways of from .75 meter to 1 meter gage. At the present time wood is the principal fuel but the supply of this fuel is not great and considerable interest is being manifest in the substitution of alcohol which can be manufactured in large quantities as a sugar by-product. The current price of alcohol, says Consul Cameron, is 22 cents a gallon,

although the cost of production is much less. Mr. Cameron is impressed, consequently, with the opportunities in this section for American concerns manufacturing locomotives using alcohol as a fuel.

Salary Reductions on the Baltimore & Ohio

Coincident with the wage reductions for employees which went into effect on July 1, the Baltimore & Ohio also reduced "in like manner the compensation of those general, division and other officers and monthly employees who in the light of the higher cost of living were granted increases in their compensation at or since May 1, 1920," according to an announcement made on July 18. The announcement continued: "While the wages of such officers and employees do not come under the decision of the Labor Board, it was deemed necessary, because of the general conditions which so adversely affect the revenues of transportation companies, that such action be taken, notwithstanding it is recognized that during the period of inflation the officers did not receive increases in their salaries at the time or of the extent generally granted to many classes of officers and employees of industrial organizations nor in proportion to the increases granted from time to time to other classes of railroad employees generally."

Traveling Engineers' Convention Postponed

The Executive Committee of the Traveling Engineers' Association has announced that the annual convention, scheduled to be held at the Hotel Sherman, Chicago, on September 6-9, 1921, has been deferred. There will be a business meeting instead at the same hotel, commencing Tuesday, September 6, at which reports on the following subjects will be considered: Distribution of Power and Its Effect on Operating Costs; Recommended Practice for Conservation of Locomotive Appurtenances and Supplies; What Are the Advantages of Self-Adjusting Wedges, the Feed-water Heater and Devices for Increasing the Tractive Power of the Locomotive in Starting and at Slow Speed? The Best Method of Operating Stoker-fired Locomotives to Obtain the Greatest Efficiency at the Least Expense; A Comprehensive Standard Method of Employing, Educating and Examining Engineers and Firemen; Operation and Maintenance of Oil-burning Engines; Revision of Progressive Examination for Firemen for Promotion and New Men for Employment; Committees on Subjects, Constitution and By-laws and Arrangements. All other committees are asked to attend and be ready to submit their reports.

Hearing on Pennsylvania Locomotive Repairs

Oral arguments before the Interstate Commerce Commission at Washington on June 20, on the question whether the Pennsylvania caused 200 of its locomotives to be repaired at the shops of the Baldwin Locomotive Works in 1920 in disregard of efficient and economical management, resulted in a complicated statistical controversy as to whether the Pennsylvania showed wise management in making this contract instead of repairing the locomotives at its own shops. However, it remained for members of the commission to bring out by questions why so little had been put into the record at the previous hearings before an examiner bearing on the charges made by the International Association of Machinists that the repair contract was made for ulterior purposes to transfer money from the Pennsylvania Railroad, to be collected from the United States Government in the form of a guaranty, and into the treasury of an outside company for the profit of the banking combine said to control the railroads. The commissioners' questions on this point merely brought out that it was simpler to make such charges than it was to attempt to prove them and the commission was left to assume the evidence of a gigantic conspiracy which has been used so extensively as publicity material.

In reply to questions by Commissioner Lewis, R. B. Gregg, who appeared as attorney for the machinists' union, said that his organization would have objected to the contract even if the Pennsylvania had paid no more than the cost in its own shops, on the ground that it caused unemployment among the railroad shop men, although it had developed that the laying off of large numbers of Pennsylvania shop men had not taken place until several months after the letting of the contract and after business had begun to fall off in the latter part of the year.

Representatives of the railroad stated that the outside repairs were necessary because the road's shops were operated to capacity during the period while the Baldwin Locomotive Works was overhauling these engines. The traffic was so heavy that even with this power, it was impossible to meet the demands of service. It was also shown that the guaranty had not placed the burden for extravagant repairs on the government. The representatives of the machinists' union failed to show that the management has deliberately tried to cause unemployment, or that the Baldwin Locomotive Works made any undue profit. The fact was brought out in the testimony that the company lost money on the first part of the contract.

MEETINGS AND CONVENTIONS

The *Chief Interchange Car Inspectors' and Car Foremen's Association* convention for this year has been postponed.

The *American Railway Tool Foremen's Association* convention which was to have been held at the Hotel Sherman, Chicago, on August 9, 10 and 11, has been postponed.

The *International Railroad Master Blacksmiths' Association* convention which was to have been held at the Hotel Sherman, Chicago, on August 16, 17 and 18, has been postponed.

The *International Railway General Foremen's Association* has decided to cancel its 1921 convention which was to have been held September 12, 13, 14 and 15 at the Hotel Sherman, Chicago, owing to the financial stress and serious business conditions.

The following list gives names of secretaries, dates of next or regular meetings and places of meeting of mechanical associations and railroad clubs:

AIR-BRAKE ASSOCIATION.—F. M. Nellis, Room 3014, 165 Broadway, New York City.

AMERICAN RAILWAY ASSOCIATION, DIVISION V—MECHANICAL.—V. R. Hawthorne, 431 South Dearborn St., Chicago.

DIVISION V—EQUIPMENT PAINTING DIVISION.—V. R. Hawthorne, Chicago.

AMERICAN RAILWAY ASSOCIATION, DIVISION VI—PURCHASES AND STORES.—J. P. Murphy, N. Y. C., Collinwood, Ohio.

AMERICAN RAILROAD MASTER TINNERS', COPPERSMITHS' AND PIPEFITTERS' ASSOCIATION.—C. Borcherdt, 202 North Hamlin Ave., Chicago. Convention September 12-14, Hotel Sherman, Chicago, Ill.

AMERICAN RAILWAY TOOL FOREMEN'S ASSOCIATION.—R. D. Fletcher, 1145 E. Marquette Road, Chicago.

AMERICAN SOCIETY FOR TESTING MATERIALS.—C. L. Warwick, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Calvin W. Rice, 29 W. Thirty-ninth St., New York.

AMERICAN SOCIETY FOR STEEL TREATING.—W. H. Eisenman, 4600 Prospect Ave., Cleveland, Ohio. Annual convention September 19-24, Indianapolis, Ind.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.—Joseph A. Andreucetti, C. & N. W., Room 411, C. & N. W. Station, Chicago, Ill.

CANADIAN RAILWAY CLUB.—W. A. Booth, 131 Charron St., Montreal, Que. Meeting second Tuesday of each month except June, July and August, at Windsor Hotel, Montreal.

CAR FOREMEN'S ASSOCIATION OF CHICAGO.—Aaron Kline, 626 N. Pine Ave., Chicago, Ill. Meeting second Monday in month, except June, July and August, New Morrison Hotel, Chicago, Ill.

CAR FOREMEN'S ASSOCIATION OF ST. LOUIS.—Thomas B. Koeneke, 604 Federal Reserve Bank Building, St. Louis, Mo. Meetings first Tuesday in month at the American Hotel Annex, St. Louis, Mo.

CENTRAL RAILWAY CLUB.—H. D. Vought, 95 Liberty St., New York, N. Y.

CHIEF INTERCHANGE CAR INSPECTORS AND CAR FOREMEN'S ASSOCIATION.—W. P. Elliott, T. R. R. A. of St. Louis, East St. Louis, Ill. Convention postponed.

CINCINNATI RAILWAY CLUB.—W. C. Cooder, Union Central Building, Cincinnati, Ohio. Meeting second Tuesday of February, May, September and November, at Hotel Sinton, Cincinnati.

DIXIE AIR BRAKE CLUB.—E. F. O'Connor, 10 West Grace St., Richmond, Va.

INTERNATIONAL RAILROAD MASTER BLACKSMITHS' ASSOCIATION.—W. J. Mayer, Michigan Central, 715 Clarke Ave., Detroit, Mich. Convention postponed.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.—J. G. Crawford, 702 East Fifty-first St., Chicago, Ill.

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION.—William Hall, 1061 W. Wabasha Ave., Winona, Minn. Convention postponed.

MASTER BOILERMAKERS' ASSOCIATION.—Harry D. Vought, 95 Liberty St., New York, N. Y.

NEW ENGLAND RAILROAD CLUB.—W. E. Cade, Jr., 683 Atlantic Ave., Boston, Mass. Meeting second Tuesday of each month, except June, July, August and September.

NEW YORK RAILROAD CLUB.—H. D. Vought, 95 Liberty St., New York, N. Y.

NIAGARA FRONTIER CAR MEN'S ASSOCIATION.—George A. J. Hochgrebe, 623 Brisbane Building, Buffalo, N. Y.

PACIFIC RAILWAY CLUB.—W. S. Wollner, 64 Pine St., San Francisco, Cal.

RAILWAY CLUB OF PITTSBURGH.—J. D. Conway, 515 Grandview Ave., Pittsburgh, Pa.

ST. LOUIS RAILWAY CLUB.—B. W. Frauenthal, Union Station, St. Louis, Mo. Meeting second Friday of each month, except June, July and August.

TRAVELING ENGINEERS' ASSOCIATION.—W. O. Thompson, 1177 East Ninety-eighth St., Cleveland, Ohio. Business meeting, Hotel Sherman, Chicago, Sept. 6, 1921.

WESTERN RAILWAY CLUB.—Bruce V. Crandall, 14 E. Jackson Boulevard, Chicago. Meeting third Monday of each month, except June, July and August.

PERSONAL MENTION

GENERAL

J. I. MAILER, master mechanic of the Fort Smith & Western, with headquarters at Fort Smith, Ark., has been appointed superintendent of motive power, with the same headquarters. The office of master mechanic has been abolished.

MASTER MECHANICS AND ROAD FOREMEN OF ENGINES

J. S. ALLEN has been appointed master mechanic of the Brownville division of the Canadian Pacific, with headquarters at Brownville Junction, Me., succeeding E. Bowie, transferred.

D. D. BRIGGS has been appointed master mechanic in full charge of the mechanical department of the Alabama, Tennessee & Northern, with headquarters at Mobile, Ala.

J. KANATSER has been appointed road foreman of engines of the Rock Island at Shawnee, Okla.; H. C. McCullough at Pratt, Kan.; B. J. Bonner at Eldon, Mo.; S. F. Hanchett at Des Moines, Iowa; H. T. Demsey at Estherville, Iowa; B. Strauss at Cedar Rapids, Iowa, and J. C. Rhodes at Trenton, Mo.

J. MCDONOUGH, master mechanic of the Atchison, Topeka & Santa Fe, with headquarters at Fort Madison, Iowa, has been transferred to the Illinois division, with headquarters at Chicago, succeeding A. L. Beardsley, resigned on account of ill-health.

G. E. PRYOR has been appointed master mechanic of the Quanah, Acme & Pacific at Quanah, Tex., succeeding L. E. Wingfield, resigned.

CAR DEPARTMENT

WILLIAM JOHN SHEPPARD has been appointed car foreman of the Canadian Pacific at Nelson, B. C. Mr. Sheppard was born at Kemnay, Scotland, September 28, 1882, and entered the service of the Canadian Pacific in September, 1906. From 1906 to 1907 he was a car repairer at Vancouver, B. C.; from 1907 to 1911, a car inspector at Kamloops, B. C., and from 1911 until his recent appointment, car foreman at Revelstoke, B. C.

SHOP AND ENGINEHOUSE

J. W. FINCH has been appointed general foreman of the Rock Island shops at El Reno, Okla., succeeding F. D. Buckley, who has been made roundhouse foreman at Eldon, Mo.

J. W. JOHNSON has been appointed general foreman of the Rock Island shops at Ft. Worth, Tex., succeeding A. F. Davis, resigned.

PURCHASING AND STORES

W. L. MANNING has been appointed assistant superintendent of stores of the Chesapeake & Ohio; W. S. McDonald, general storekeeper, Western Division, and R. L. Morris, storekeeper, each with headquarters at Huntington, W. Va.

G. H. PINION, assistant purchasing agent of the Texas & Pacific, has been appointed general storekeeper, with headquarters at Marshall, Tex., succeeding A. D. Walther, resigned to accept service in another department. The position of assistant purchasing agent has been abolished.

FORTY CENTS A PLATE is the cost of a good noon-day meal at a lunch room which seventeen shop foremen of the New York, New Haven & Hartford have established for themselves at Van Nest, New York City; and at that price they have accumulated in two and a half years a reserve fund of about $500. Van Nest is not well provided with restaurants and so these men got the company to give them an old passenger car and they fixed it up as a dining car (without trucks). The company furnishes hot water and gas. They have a woman cook, and, with a present membership of 40 (foremen and clerks), and an average daily company of eaters of 26, they are maintaining the establishment without difficulty. The woman reporter of the New York Evening Post, who gives these facts, says that this unpretentious "dining car" is beautiful with rosebushes, and that the odor from the kitchen is "savory."

SUPPLY TRADE NOTES

Victor M. Summa has opened an office as general consulting engineer at 415 Merchants-Laclede building, St. Louis, Mo.

The Walworth Manufacturing Company has removed its general offices from its Boston factory, First and O streets, to Pearl and High streets, Boston, Mass.

M. J. O'Connor has been appointed general sales manager of the Gary Industrial Paint Company, with headquarters at 20 East Jackson Boulevard, Chicago.

The Oxweld Acetylene Company, Newark, N. J., has removed the offices of its foreign sales department from Newark, N. J., to 30 East Forty-second street, New York.

Charles Copeland, assistant treasurer of E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., has been elected secretary, to succeed Alexis I. du Pont, deceased.

The Webster & Perks Tool Company, Springfield, Ohio, has sold the grinding and polishing stand and accessory department, of its business, to the Hill-Curtis Co., Kalamazoo, Mich.

E. J. Brennan, formerly superintendent of motive power of the Chicago, Milwaukee & St. Paul, Lines East, is now sales manager for The Rogotchoff Company, Baltimore, Md.

The National Machinery Company, Tiffin, Ohio, has opened an eastern sales office in room 637, Knickerbocker building, Broadway and Forty-second street, New York City, in charge of F. J. Mawby.

The Dominion Oxygen Company, Ltd., has begun work on a new oxygen plant at Montreal, Que., to cost $250,000. The building will be 100 ft. by 100 ft., and will be a duplicate of the company's Toronto plant.

The Universal Crane Company, Cleveland, Ohio, has appointed the Allied Machinery Company of America, 51 Chambers street, New York, as its foreign representative, the territory including all countries, except the United States and Canada.

E. E. Hudson, whose election as president of the Waterbury Battery Company, Waterbury, Conn., was announced in the May issue of the *Railway Mechanical Engineer*, died on June 27 at his home in Maplewood, N. J.

Barbour, Love & Woodward, Inc., machine tool dealer, formerly at 149 Broadway, has moved its temporary office and warehouse from 131 Washington street to its new offices and showrooms at 45 West Eighteenth street, New York City.

Goddard & Goddard Company, Inc., Detroit, Mich., has opened an eastern sales office and permanent exhibition of milling cutters in the rooms of the Manufacturers' Exhibit, Inc., 45 West Eighteenth street, New York. James W. Sederquist, eastern sales manager, is in charge of the sales office and exhibit.

De F. Lillis, who has been placed in charge of the recently established office of the Dressel Manufacturing Corporation in the Railway Exchange, Chicago, as noted in the July issue of the *Railway Mechanical Engineer*, was for many years connected with the motive power department of the New York Central.

H. A. Paarman, assistant to secretary of the Burden Iron Company, Railroad & Steamship division, 3711 Grand Central Terminal, New York City, has been appointed secretary, to succeed W. J. Caton, deceased. Mr. Paarman will also continue to serve in the sales department of the Sanitation & Supply Company, New York City.

A. M. Castle & Co., Chicago, has started work on the construction of a new steel warehouse at Blackhawk and North Branch streets, Chicago. The building will be 211 ft. by 232 ft. of fireproof construction. The west end of the building for 75 feet is to be two stories in height and the second floor will provide office space 75 ft. by 211 ft. for the general offices of the company.

The Universal Packing & Service Company, Chicago, in addition to handling spring journal box packing, has enlarged its or-

ganization to take care of the railroad field and mid-western commercial field for the development and sale of Rawlplugs, a device which enables an ordinary screw to hold in any material. The Rawlplug Company has its offices at 461-475 Eighth avenue, New York City.

E. W. Crellin, president of the Pittsburgh-Des Moines Steel Company, Pittsburgh, Pa., has retired, and W. H. Jackson, secretary and treasurer, has been elected to succeed him; P. E. Guibert and W. W. Hendrix have been elected vice-presidents, and George A. Smith, secretary and treasurer. A. C. Pearsall has been appointed general manager of the Des Moines, Iowa, branch, succeeding Mr. Smith, who has gone to Pittsburgh, Pa.

Henry S. Manning, who retired in 1905, as senior partner of Manning, Maxwell & Moore, New York, died on July 9, in New York City, at the age of 76. Mr. Manning established the firm of H. S. Manning & Co., New York. In 1880 its name was changed to Manning, Maxwell & Moore, and in 1905 the present corporation was organized. After leaving Manning, Maxwell & Moore, Mr. Manning became interested in the firm of Milliken Brothers, New York. He was a member of the executive committee of the Kansas City, Mexico & Orient Railroad.

The Western Electric Company has opened a new warehouse at 395 Hudson street, New York City. The building occupies the entire square block bounded by Hudson, West Houston, Greenwich and Clarkson streets, an area of 338 ft. by 200 ft., with a total floor space of 706,000 sq. ft. Several departments of the Western Electric Company have already moved into the new quarters, but the New York shops and the supply divisions of the Eastern district territory, which includes New York, New Jersey, Pennsylvania and the New England states, and the International Western Electric Company will not remove to the same building at the present time.

Crerar, Adams & Company, Chicago, Ill., western sales agent for B. M. Jones & Co., Inc., New York, will in future carry a complete stock of Double Mushet high speed steel, also Titanic carbon tool steels, and Taylors' Best Yorkshire Iron, in Chicago. F. W. Clifford, associated for a number of years with Crerar, Adams & Co., as a tool steel expert, will in future specialize on Mushet and Titanic tool steels. The Connelly & Kendal Company, 115 St. Clair avenue, N. W., Cleveland, Ohio, is now managing the Jones company's Cleveland branch, and R. G. White, who was manager of the Cleveland branch, has been appointed special western representative, with headquarters in Chicago.

Will H. Bloss, manager steam railroad sales, of the Ohio Brass Company, Mansfield, Ohio, died suddenly from heart failure at his home in Mansfield on June 22. Mr. Bloss was born on April 4, 1869, and received his engineering training at Indiana University. He started his career in railroad work and subsequently was division engineer on the Santa Fe. He later served as chief engineer of the Indiana Union Traction Company. In 1906 he went to the Ohio Brass Company from the Buda Company of Chicago and was district sales manager in some of the central states until about a year ago. From that time he had devoted his effort to electrification development and other steam railroad problems.

William Aldrich, who has recently been in charge of thermit welding in the southern territory of the Metal & Thermit Corporation, New York, has been transferred to the western territory. William H. Moore, who recently was assigned to the Chicago territory, now has charge of the southern territory. This corporation has constructed and will shortly place in operation in south San Francisco, Cal., a large new plant for the production of detinned billets, in addition to the detinning plants already operated by this company for several years at Chrome, N. J., and east Chicago, Ind. E. Kardos, superintendent, will be in charge of the new plant, which includes a large welding shop. The estimated cost of this plant is $800,000. The San Francisco offices of the corporation have been removed from 329-333 Folsom street, to the new south San Francisco plant.

C. J. Burkholder and Frank H. Cunningham have been appointed special engineers of the Franklin Railway Supply Company, Inc., New York. Mr. Burkholder began railroad work at Tyrone, Pa., and subsequently served first as locomotive fireman and then as locomotive engineman on the Union Pacific. He then went with the Kansas City Southern, as locomotive engineman, later serving consecutively as traveling engineer, trainmaster, general road foreman of engines and division superintendent. He then became mechanical representative of the Economy Devices Corporation, which later merged into the Franklin Railway Supply Company, Inc. In November, 1918, he resigned from the position of western sales manager of the Franklin Railway Supply Company to become master mechanic of the Kansas City Southern, which position he held until his appointment as above noted. Mr. Cunningham was born in Roanoke, Va., on May 23, 1886. After serving an apprenticeship as machinist on the Norfolk & Western, he attended the University of Virginia. Following his graduation with the degree of mechanical engineer, he returned to the Norfolk & Western as machinist, subsequently becoming material inspector, mechanical inspector, assistant engineer of tests and supervisor of locomotive stokers. In 1914 he went with the Standard Stoker Company as fuel engineer, being appointed later to plant manager at Erie, Pa., and assistant general manager, from which position he now resigned to enter the services of the Franklin Railway Supply Company, Inc., as above noted.

F. B. Jewett, chief engineer of the Western Electric Company, has been elected a vice-president and director of the company, continuing his present duties in charge of the technical forces of the company. Dr. Jewett, who was a lieutenant-colonel in the Signal Corps during the war and was decorated with the Distinguished Service Medal, was born at Pasadena, Cal., on September 5, 1879. He was graduated from the electrical engineering course of Throop Polytechnic Institute, of Pasadena, in 1898. From that time until June, 1902, he was a graduate student at the University of Chicago. During the next two years he was instructor in physics and electrical engineering at the Massachusetts Institute of Technology. Dr. Jewett's connection with the commercial telephone business dates from September, 1904, when he became transmission engineer for the American Telephone & Telegraph Company. While acting in this capacity, the loading of eight gage circuits was perfected; phantom tables and phantom loading for open wires and cables were developed; the New York to Denver circuit and line was engineered and also the Boston to Washington underground cable. In April, 1912, Dr. Jewett became assistant chief engineer of the Western Electric Company in charge of all development and research work. He has been chief engineer since 1916. Dr. Jewett was an advisory member of the Special Submarine Board of the Navy and contributed much towards the perfection of devices for detecting hostile submarines. The perfection of wireless telephoning is one of the undertakings which was completed under his direction.

Waterbury Battery Company

The Waterbury Battery Company, Waterbury, Conn., has completed a reorganization of its officers and directors, which has been occasioned by the deaths of Charles B. Schoenmehl and E. E. Hudson. The officers of the company are now Martin L. Martus, of Waterbury, Conn., president; G. A. Nelson, vice-president and general sales manager at New York; Francis T. Reeves, treasurer, and Harold B. Schoenmehl, secretary, both at Waterbury. The directors are: Francis T. Reeves, Martin L. Martus and Darragh De Lancey.

Martin L. Martus, who has been elected president, has been associated with the company since April, 1911; for the past nine years as secretary and factory manager. He was born in New Haven, Conn., and became associated with the Scovill Manufacturing Company in 1901. In 1906 he was chief engineer for one of the subsidiary plants of the American Brass Company, and in 1911 became associated with the Waterbury Battery Company as factory manager, which position he has held until the present time.

Judge Francis T. Reeves, treasurer, was born in Thomaston, Conn., and has been a director of the Waterbury Battery Company since October, 1916, and its general counsel since 1914. He is director and trust officer of the Manufacturers National Bank, of Waterbury, Conn., and is a practising attorney in Waterbury.

Harold B. Schoenmehl, the newly elected secretary, is the eldest son of the late Charles B. Schoenmehl. He has been associated with the Waterbury Battery Company for the last six years, engaged in laboratorial and experimental work.

Darragh De Lancey, the newly elected director, was formerly president of the Waterbury Chamber of Commerce and during the war served with the War Department and the United States Shipping Board.